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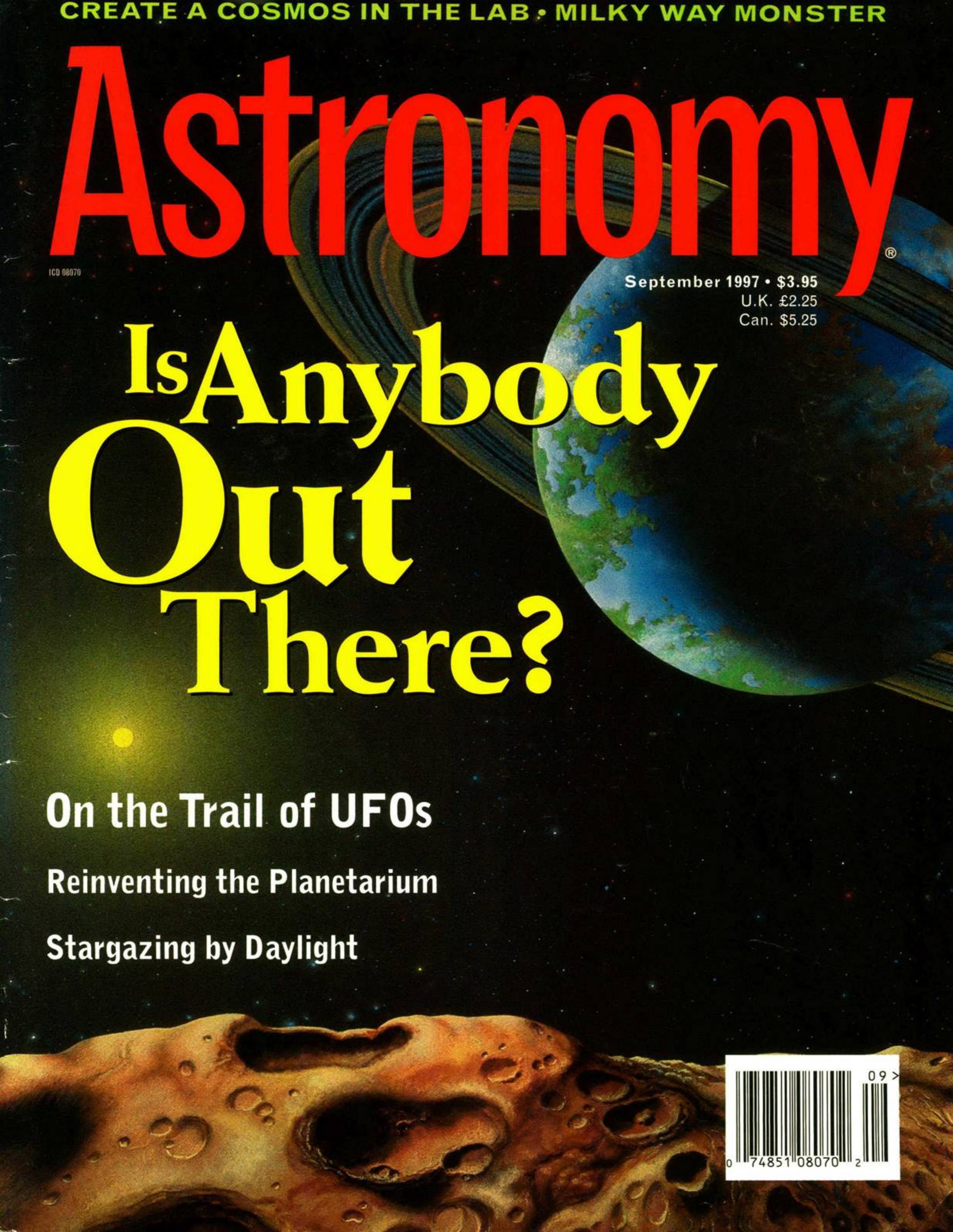

Is Anybody Out There?

On the Trail of UFOs

Reinventing the Planetarium

Stargazing by Daylight

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LX50

Advanced technology at the most affordable prices *ever.*

■ **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

■ **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

■ **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below).* A North-South switch permits telescope operation anywhere in the world.

■ **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

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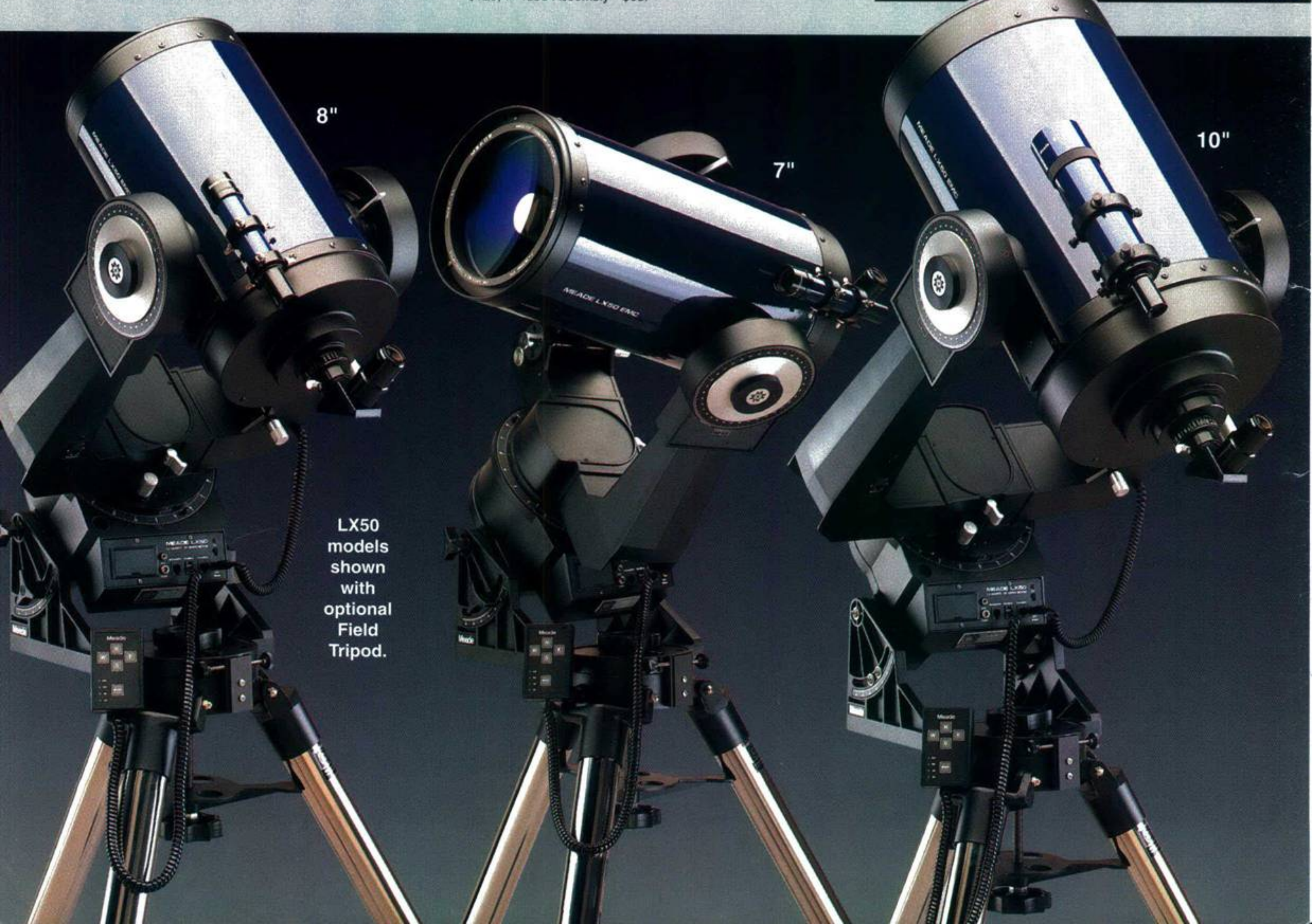

LX50 models shown with optional Field Tripod.

The largest-selling serious telescopes in the world.

LX200

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8"
7"
10"
12"
MEADE LX200 EMC
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September 1997 • Vol. 25, No. 9

Astronomy®

COVER ART: Lynette Cook

FEATURES

30 **A Field Guide to UFOs**
Although thousands are reported each year, nearly all UFO sightings turn out to be something ordinary. *Philip J. Klass.*

COVER

36 **When E.T. Calls Us**
The search is under way, but what would happen if humans receive a message from extraterrestrials? *Seth Shostak.*

42 **Does a Monster Lurk Closeby?**
Hidden behind a wall of dust, the center of our galaxy long remained an enigma. Yet most astronomers now believe that a massive black hole lurks there. *Bonnie Schulkin.*

48 **Reinventing the Planetarium**
If you haven't visited a planetarium recently, get ready for a surprise: New technology has transformed many of them into dazzling showcases. *Daniel Pendick.*

54 **Cooking Up a Cosmos**
The physicist who developed inflation theory examines whether an advanced civilization could create its own universe. *Alan Guth.*

72 **Blue Sky Gazing**
Tired from those late nights under the stars? Why not explore the many treats awaiting you under a sunlit sky? *Bob Berman.*

78 **Ask Astro**
The editors of *Astronomy* answer your questions about the sky and the universe.

80 **Tabletop Star Cruiser**
Meade's 3.6-inch ETX telescope puts razor-sharp optics in a package that's a breeze to set up and use. *Steve Edberg.*

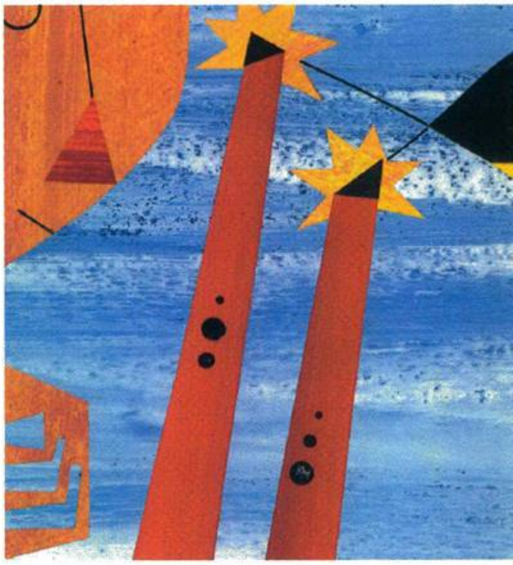
86 **Sweeping the Bottom**
If galaxies are your cup of tea, don't overlook the telescopic treasures awaiting you in the southern constellations of Grus and Piscis Austrinus. *Richard Jakiel.*

80 Tabletop Star Cruiser

Astronomy: Rebecca Saliture

72 Skygazing by Daylight

Jerry Schad



30 On the Trail of UFOs

UPI/Corbis-Bettmann

DEPARTMENTS

78 **Ask Astro** Luke Dodd

6 **Behind the Scenes**
- Looking for Life, Any Size

16 **Talking Back**

20 **AstroNews**
- Lunar Water? The Jury's Still Out
- The Changing Weather of Mars
- Yardstick to the Coma Cluster
- Cosmic Rain of Mini-Comets

60 **Sky Almanac**
- The moon slides in front of Saturn on the 18th, but don't let this striking occultation overshadow brilliant Jupiter or Mercury at its best. *Martin Ratcliffe and Alister Ling.*

90 **Star Stuff**

Products
- Trappings for Small Telescopes
- Dobsonian Reflector Kit
- Pickup Truck Tent

Books
- Planet Quest: The Epic Discovery of Alien Solar Systems
- Worlds Unnumbered: The Search for Extrasolar Planets

Bytes
- Linux for Astronomy
- The Planets and The Universe

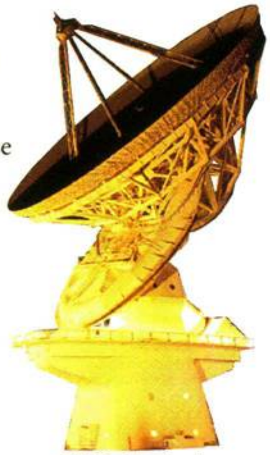
96 **Looking Ahead**

110 **Advertiser Index**

111 **Hot Shots**
- An Unforgettable Anatomy Lesson

118 **Ultimate Exposure**

54 **Create a Cosmos in the Lab** Philip Anderson


36 **Is Anybody Out There?**

Seth Shostak

48 **Reinventing the Planetarium**

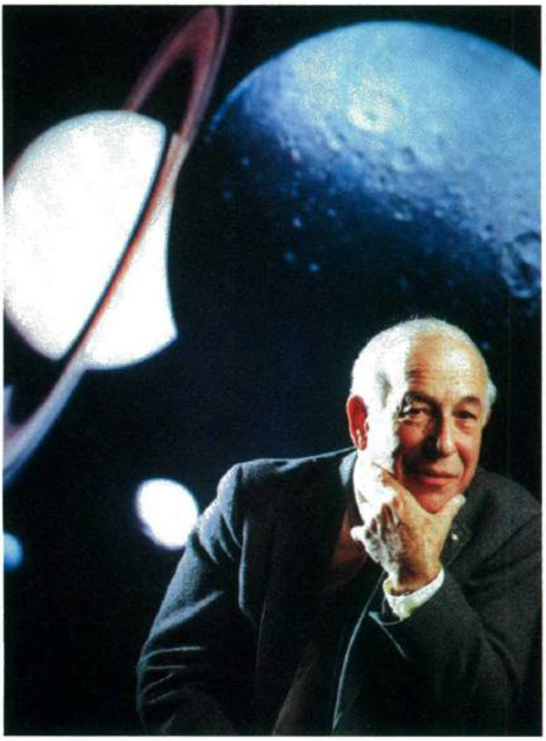
James Steinkamp — Steinkamp/Ballogg Chicago

BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Looking for Life, Any Size

Phillip Klass shares with us stories of tracking down the truth behind hundreds of Unidentified Flying Object reports and finding the objects in question to be planets, stars, fireballs, birds, or the odd moon. For 45 years Klass has been a writer and editor at *Aviation Week & Space Technology* and written several books about his own adventures and those of other famous UFO trackers.



Rizzi Photography

Phillip Klass chases UFOs all over this planet. He has had to face down many fictions, some intentional hoaxes.

Here, on page 30 of *Astronomy*, Klass reveals in "A Field Guide to UFOs" that identifiable sources have been found for all but a very few objects. Those that couldn't be explained, could not be proven as alien spacecraft either. "I can think about no more exciting story I could write than to be able to report that I have finally found a UFO case that defies any possible prosaic explanation. I would expect to win a Pulitzer Prize, a giant bonus, and great fame," says Klass.

Those who search for extraterrestrial intelligence in a wider universe want to be ready for any lifeform that may wish to talk to us. On page 36, Seth Shostak, public program scientist at the SETI (Search for Extraterrestrial Intelligence) Institute in Mountain View, California, takes us through an imaginary first contact with ET and then deliberates on the social and political ramifications of such contact.

Klass reveals the errors and hoaxes associated with UFO sightings here on Earth, while Shostak analyzes the hopes and fears attached to contact of the first, second, or third kind.

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Add the optional LX10 Declination Motor for dual-axis corrections at 2x.

Meade 8" LX10
Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

MEADE 8" LX10

All the optical performance of Meade 8" LX50 and LX200 Schmidt Cassegrains...for only *$995!*

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *No other similarly-priced 8" Schmidt-Cassegrain offers such a range of standard features* — or such a range of important options for special applications. *Standard-equipment includes:*

Super Multi-Coated Optical System: The LX10 includes the *exact same* 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. Super multi-coatings (not available even as an *option* on competing 8" telescopes) are included with every LX10 optical system, for the highest levels of light transmission and image contrast.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. Ball bearings on the polar axis complement the precise action of the internal worm gear system.

Cordless, DC-Powered Electronic Motor Drive: A drive system that includes an electronically-regulated DC servo motor for automatic *sidereal-rate* tracking. The drive is powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes. Both the standard-equipment hand controller and the optional electric Declination motor plug into the telescope's control panel.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); MA25mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions.
$995. (+ $65 packing & shipping in the 48 states)

LX10 Field Tripod	**195.**
LX10 Electric Declination Motor System	**85.**
#2014 Magellan I Telescope Computer System for LX10, with 12,218-object database	**375.**

The 94-page Meade 1997 General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers. Prices shown are suggested U.S. mail-order prices.
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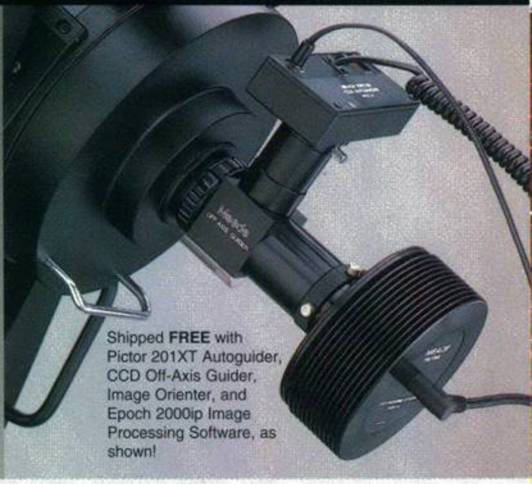
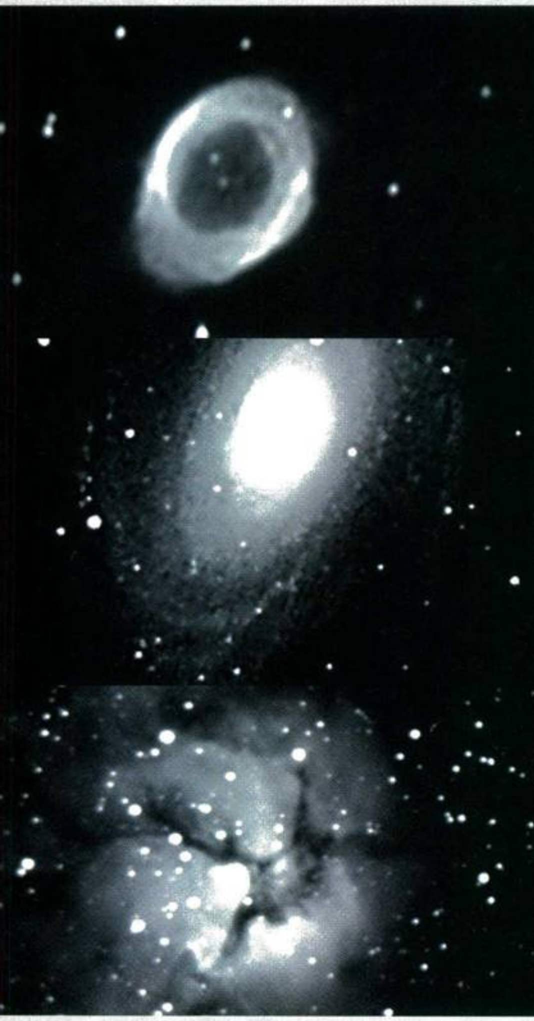
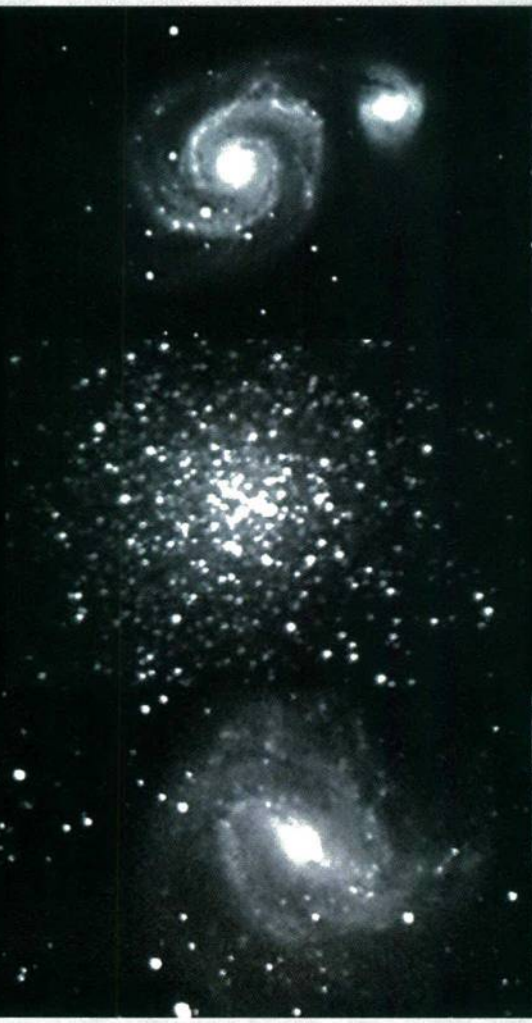
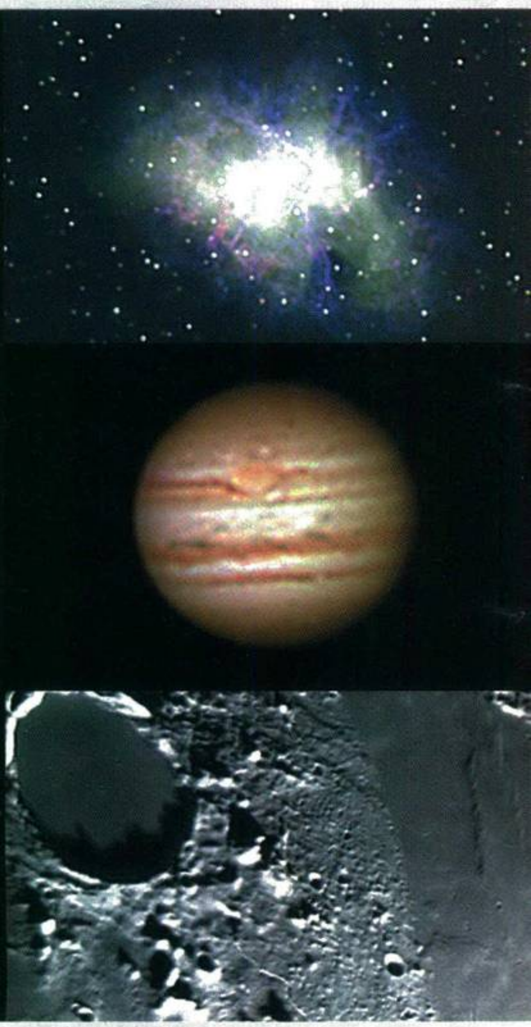

Shipped **FREE** with Pictor 201XT Autoguider, CCD Off-Axis Guider, Image Orienter, and Epoch 2000ip Image Processing Software, as shown!

Revolutionary Meade Pictor CCD's are now the world's largest-selling autoguiders and imagers for the amateur astronomer. No other electronic imaging systems offer such an incredible range of capabilities at such amazing price levels. At only **$495** the **Pictor 208XT** produces on the PC display fine, high-resolution 8-bit images *in seconds* of the Moon and planets, or, in 2 or 3 minutes, of thousands of deep-space objects. At **$695** the **Pictor 216XT** enables advanced 16-bit imaging and is *by far* the finest autoguider/imager ever made available at under-$1000. At **$1695** the **Pictor 416XT** permits professional-level imaging capability for the amateur astronomer: an electronic camera capable of producing with amateur telescopes images of the Moon, planets, and deep-space that match or exceed the photographic images obtained with many observatory telescopes. All models are available for immediate shipment. ***For complete information on Meade CCD imaging systems write, call, or fax for your free copy of the 94-page Meade 1997 General Catalog.***


Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot.


Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.


Pictor 416XT images: Crab Nebula (M1), 25" reflector, Jack Newton; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Moon (crater Plato), 16" f/6 reflector, Dr. Donald Parker.

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MEADE ETX

90mm Maksutov-Cassegrain

MEADE SUPER PLÖSSL
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Meade ETX Astro Telescope. Shown with optional #64 Photo Adapter.

SPECIFICATIONS: ETX Astro Telescope—Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.* **$595***
(+ $20 packing and shipping in the 48 states)
*Suggested U.S. mail-order retail price.

Now you can have diffraction-limited imaging and ultraportability ...at only *$595*, *complete!*

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of much larger apertures. **Equatorial Fork Mount:** Precise polar alignment in *seconds,* just by extending the center tripod leg to read your latitude on the inscribed scale. **Cordless Motor Drive:** The internal drive system operates from 3 AA-size batteries that power the motor drive for more than 50 hours. A North-South switch permits operation anywhere in the world. **Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter. **Standard accessories** include a Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm erect-image viewfinder.

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MEADE
STARFINDER DOBSONIANS

No other competing Dobsonians include this listing of *standard-equipment* features:

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

Multi-Coated MA25mm Eyepiece (1.25"): The Meade Modified Achromatic 25mm eyepiece yields sharp, high-resolution imaging to the field edge.

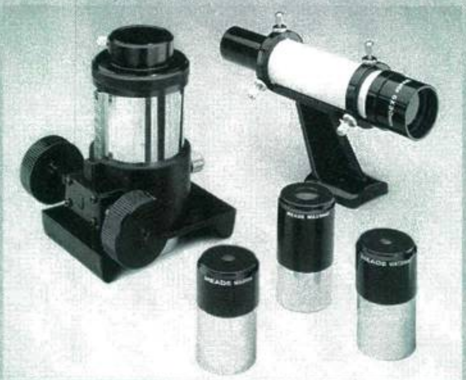
5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Starfinder Dobsonians include the same strong, spiral-wound Sonotube™ optical tubes used on Starfinder Equatorials *(right)*, tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package only $49.95!



Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*

1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*

3 - **Meade MA9mm, 12mm, and 25mm** multi-coated eyepieces, 1.25" barrel — eyepieces for the full range of lunar, planetary, and deep-space observing. *(reg. $37.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $223.75!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

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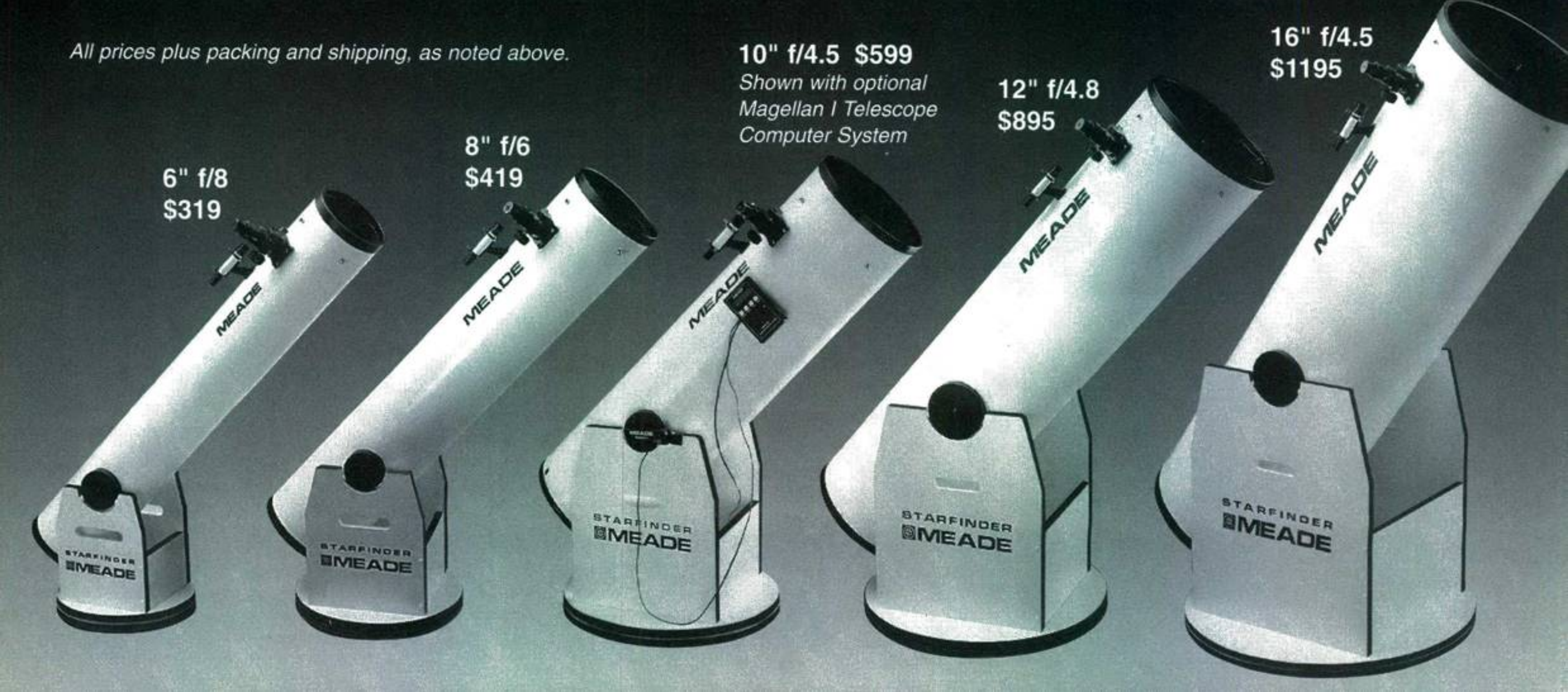
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***

All prices plus packing and shipping, as noted above.



6" f/8
$319

8" f/6
$419

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12" f/4.8
$895

16" f/4.5
$1195

MEADE STARFINDER EQUATORIALS

DC-powered drive systems for fully automatic tracking, and a wide range of standard-equipment features:

Professional-Grade Optical System: Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Accessories and Components: #637 6 x 30mm viewfinder with wide 7° field; multi-coated MA25mm eyepiece (1.25"); strong, durable, spiral-wound optical tube with attractive white finish.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

MEADE
MAGELLAN II
COMPUTER-CORRECTOR
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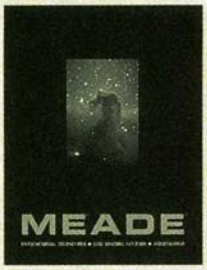
Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, ***for a total of $29.95!*** *Purchased separately, the 2 eyepieces sell for $75.90.*



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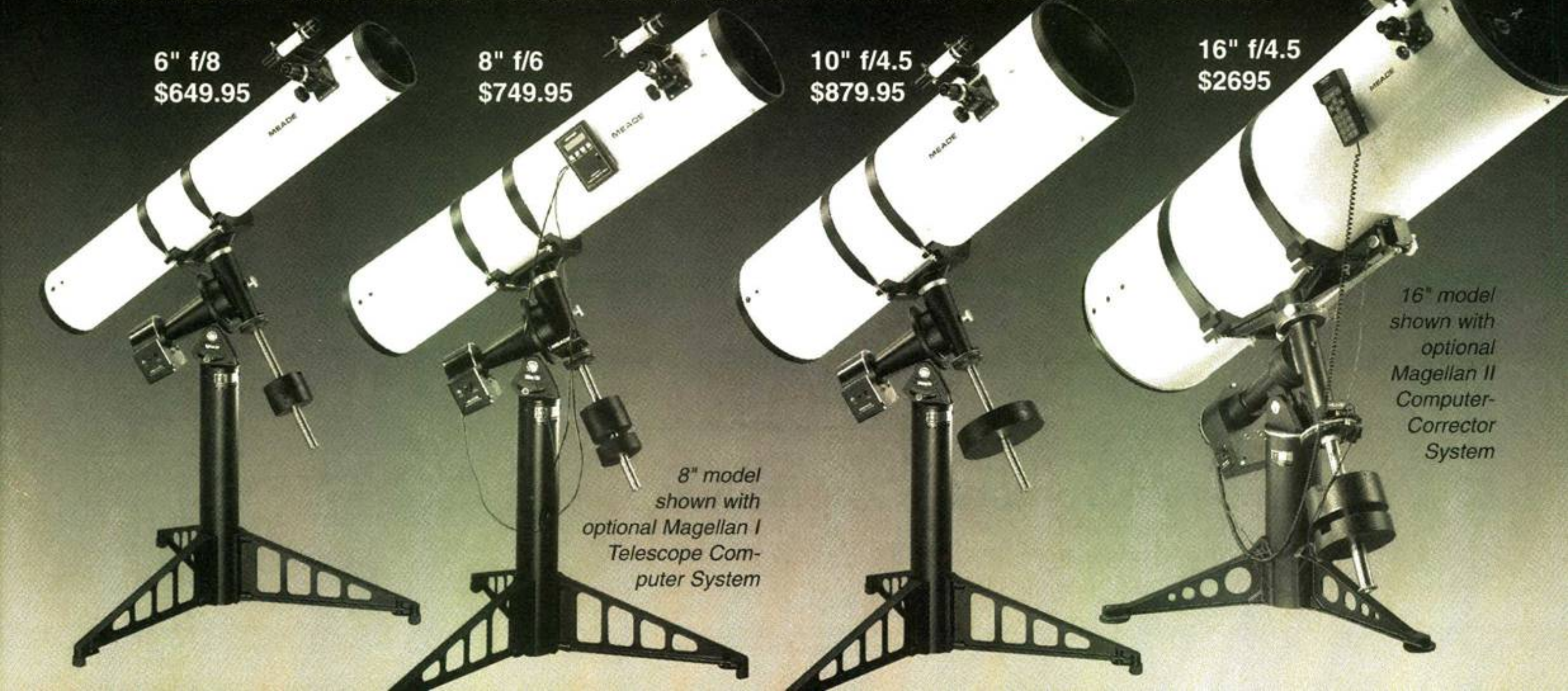
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



6" f/8
$649.95

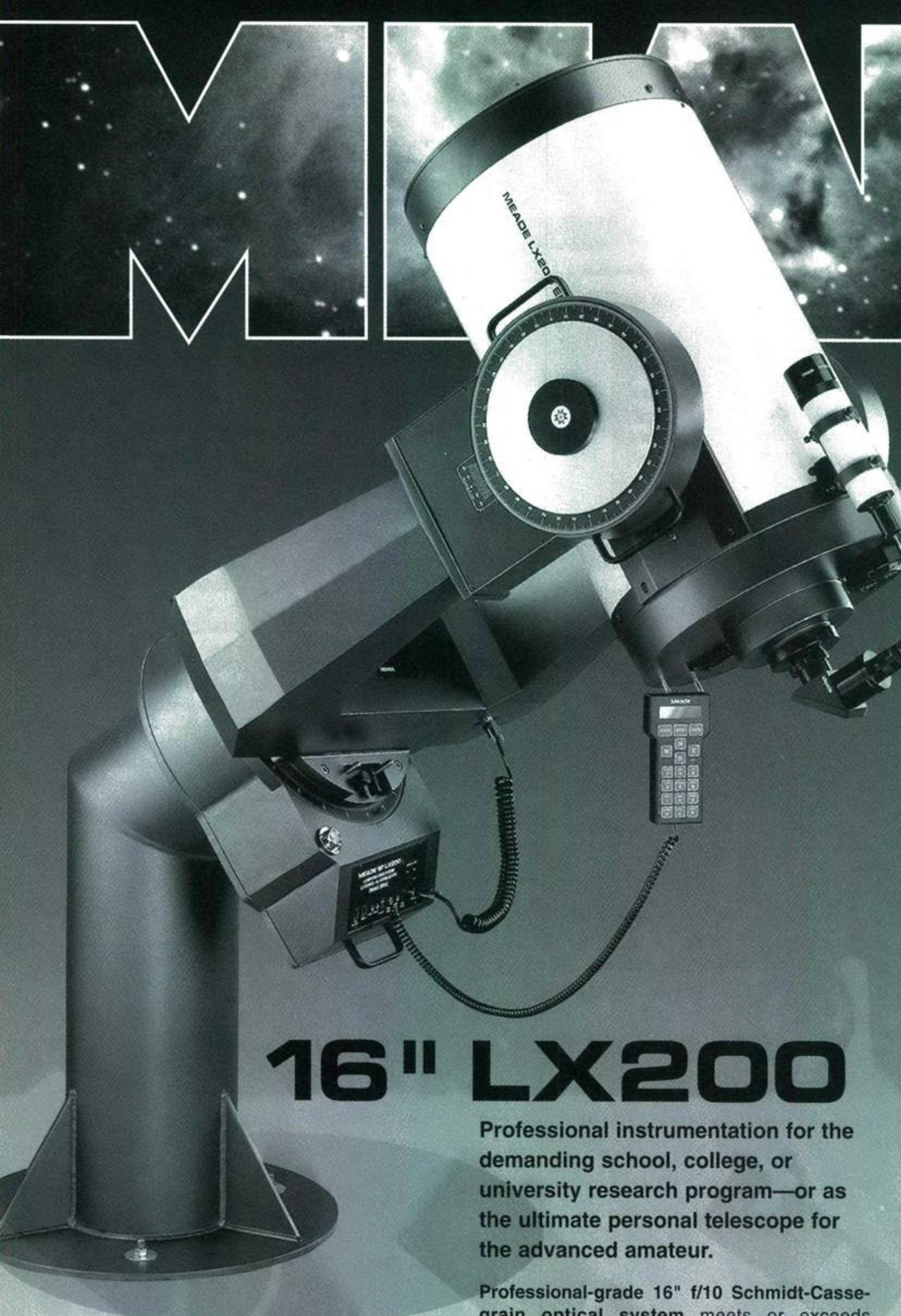
8" f/6
$749.95

10" f/4.5
$879.95

16" f/4.5
$2695

8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System



16" LX200

Professional instrumentation for the demanding school, college, or university research program—or as the ultimate personal telescope for the advanced amateur.

Professional-grade 16" f/10 Schmidt-Cassegrain optical system meets or exceeds advanced requirements; includes BK7 correcting plate with EMC super multi-coatings for high UV transmission. ■ **Massive one-piece fork mount** permits substantial auxiliary equipment to be piggybacked with rock-solid stability. ■ **Large 11" worm gears** on both axes, with factory-programmed Smart Drive™; periodic error less than 5 arc seconds. ■ **Automatic GO TO capability** to any object in the onboard 64,359-object database or to any input R.A. and Dec. ■ **High-Precision Pointing™** to within one arc-minute in the GO TO mode. ■ **DC servo drive systems** with integrated encoders and planetary gearboxes; encoder resolution: 0.13 arc secs. ■ **Six pushbutton-controlled drive-speed rates,** from photo-guide to fast-slew on both axes, simultaneously. ■ **Microprocessor controlled sidereal-rate tracking** in AZ or EQ modes with quartz accuracy. ■ **Home-Pulse Acquisition** permitting remote alignment and operation through a modem link to the telescope's RS-232 interface. ■ **Control panel connectors** for optional systems including CCD autoguiders and imagers, electric focuser, and the Meade **#1222 Field De-rotater** for long-exposure astrophotography in the AZ mode. ■ Available with **supergiant transportable field tripod** (2-person field set-up in less than 10 minutes); **permanent altazimuth pier** (permitting the entire instrument to be housed in a 2-meter dome); or **permanent equatorial pier** (in cases where piggybacked astrocameras do not permit field de-rotation).

Meade 16" LX200 Schmidt-Cassegrain, with Supergiant Transportable Field Tripod.

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The Meade 16" LX200 is in continuous production at the Meade Irvine, Calif. factory. **Delivery time:** 4 to 12 weeks. ***Price:*** *$14,950, complete with supergiant field tripod, plus $385 packing and shipping in the 48 states;* prices slightly higher with permanent altazimuth or equatorial pier.

MEADE EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™
2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (4.27)

Series 4000™
Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 4000™
Ultra Wide Angle
84° field;
multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25". **$149.95** (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$129.95** (3.45)

Series 3000™ Plössls
50° field; multi-coated

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

Series 4000™
f/6.3 Focal Reducer/ Field Flattener

f/6.3 FOCAL REDUCER/FIELD

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (3.60)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

Series 3000™ Plössl 40mm 44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters. Apparent field: 44°. **$79.95** (3.79)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (3.45)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (3.45)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.** each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

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2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25". **$59.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera. **$39.95** (2.98)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$99.95** (5.87)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera. **$39.95** (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera. **$26.95** (2.98)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces). **$42.95** (3.45)

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Was the Universe Made for Life?

I was captivated by James Trefil's piece in June's *Astronomy* and want to congratulate you for publishing what even the author describes as perhaps mystical science. Though I think the "anthropic" principle is badly misnamed, I'd like to quote from a book by an Australian author, Paul Davies, who for years has written about it in one form or another.

In *The Mind of God* Davies writes, "Our existence in this universe is not a mere quirk of fate, an accident of history, an incidental blip in the great cosmic drama . . . [our presence here] is of fundamental significance. Through conscious beings the universe has generated self-awareness. We are children of the universe." This I think best captures the force of the "anthropic" principle. — *George Karaolis, Melbourne, Australia*

Isn't this the wrong question? Is the anthropic principle anything more than a tired survival of medieval church thought? Isn't it readily apparent that life designed itself for the universe, not the other way around?

Surely the universe came first, and life found niches. Had the astrophysical principles been different, a different spectrum of life would have evolved. Had cells been inappropriate to the conditions, we'd have been, say, living crystals, or some other such thing. If escape velocity could be attained at a leap, we'd either float, or cling, or be heavy to the max. The hypothetical examples are endless.

The point is, we're the adaptation, not the universe — which is busy adjusting to far grander-scale difference. Let's bury anthrocentrism, comforting though it may feel, and get on with exploring the riches of our amazing surroundings, to which we can always hope we're not completely irrelevant! — *Robert Coltman, Chelmsford, Massachusetts*

Don't Forget Dactyl

I enjoyed the list of astronomical superlatives in the June 1997 issue ("The Biggest, The Brightest, The Best"), but must make one correction. Under "Biggest and Smallest Satellites" you listed Deimos as the smallest satellite in the solar system. It should instead be Dactyl, the satellite of asteroid 243 Ida. Deimos is a whopping 15 km long, but Dactyl is only 1.6 km long; its volume and mass are a mere thousandth that of Deimos.

I have to stick up for poor little Dactyl because I was the person who suggested its name. The Galileo imaging team had the right to select a name but they chose to solicit suggestions from the public. Mine, drawn from the mythology of the childhood of Zeus, which is also the source of Ida's name, was selected. I have just completed a photomosaic map of Ida itself, which readers may find at http://www.geog.uwo.ca/Stooke.html, and sometime soon I hope to add Dactyl to my list of mapped small worlds. — *Philip Stooke, London, Ontario, Canada*

NASA/JPL

Ida's satellite Dactyl is only 1.6 km long.

Richard Talcott responds: You raise a good point — Dactyl could well be considered the smallest natural satellite in the solar system. In many ways it's a question of semantics. We used the tradi-

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tional definition of a satellite being a celestial body revolving around a planet (eliminating poor Dactyl). But you could just as easily choose a definition that would include Dactyl or, for that matter, the tiny chunks of ice and rock that make up the rings of the gas-giant planets.

A Planet for 51 Pegasi?

I read the article in the June 1997 AstroNews section ("Is the 51 Pegasi Planet Dead") with considerable interest. I agree with Mayor and Queloz, the two scientists who discovered the purported planet, that for David Gray to conclude that no such planet exists is premature. Gray supports his hypothesis on an assumption that has not been proven: that the shape of a sun cannot be affected by a planet. Who says that it can't even be a pure coincidence? Would anyone have thought that an orbiting body would arbitrarily position itself with only one side facing its partner? Or how about a magnetic pole at 90 degrees to the spin pole?

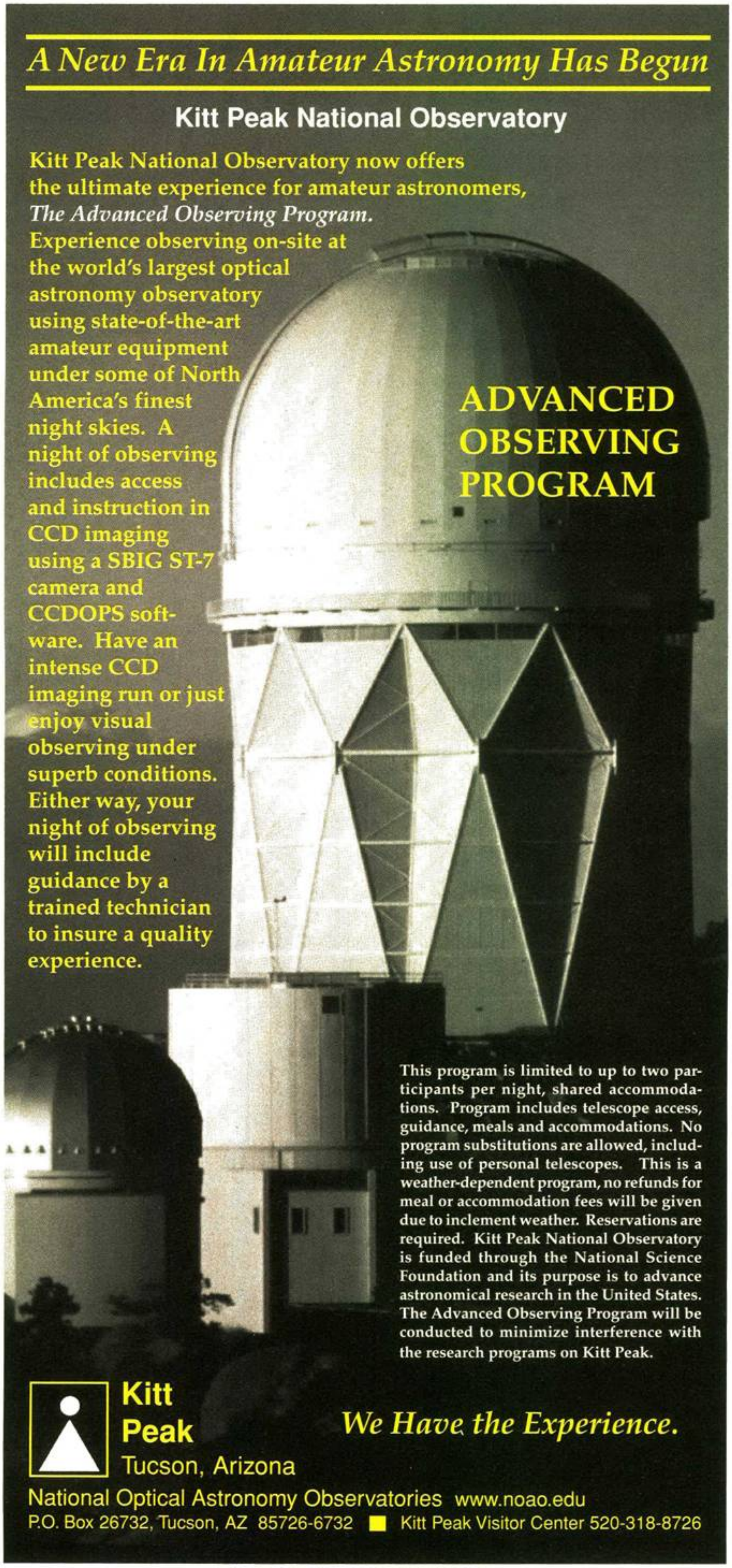
Can anything in the universe safely be considered impossible? We are constantly modifying our picture of the possible as we collect more information. Until someone takes a trip to 51 Pegasi and sees what's there first hand (or we develop a better telescope), no one can say for sure that there is or is not a planet there. The evidence to support each conclusion can be presented, and that's the best we can do for now.
— *John R. Carter, Sunnyvale, California*

Pencils and Pens

During the height of the space race in the 1960s NASA decided it needed a ball-point pen to write in the zero-gravity confines of its space capsules. After considerable research and development, the Astronaut Pen was developed at a cost of $1 million (U.S.), say some reports. The Soviet Union, faced with the same problem, used a pencil.
— *Anonymous e-mail correspondent*

Brazilian-Built Scope

A long-time subscriber to *Astronomy*, I am a professor of astronomy in Guarujá, a town of 250,000, not far from Santos, one of Brazil's largest ports. To use while teaching my students, I built a 12-inch f/6



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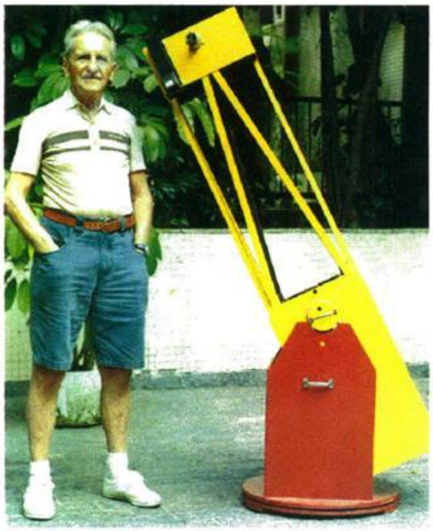
Waclaw Cywinski

Waclaw Cywinski and his home-built scope.

Photo Corrections

The lower image of Uranus on page 71 of the July 1997 issue, attributed to Hubble, is mine. I've always liked it as it was difficult to get, but I didn't realize it could be mistaken for a Hubble shot! —*Gregory Terrance, Lima, New York*

John Shibley responds: Kudos! It's not often an astrophotographer's work gets mistaken for a Hubble photo. Also, the photo of Hale Bopp's dual tails on page 126 of the July issue, attributed to Carl Weber, was actually taken by Michael Stecker. Our apologies for the mix-ups. ■

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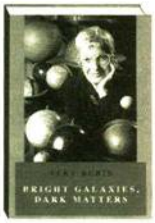
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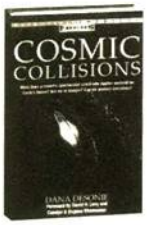
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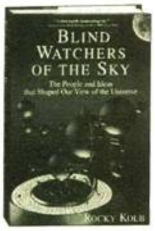
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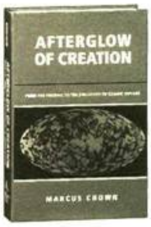
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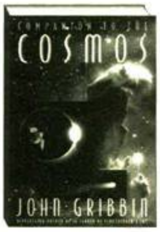
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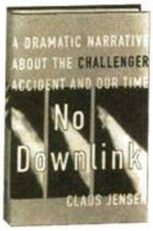
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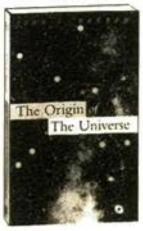
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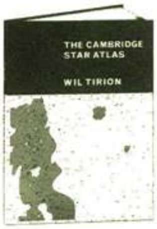
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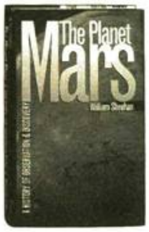
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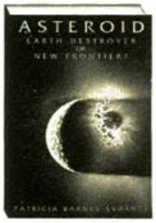
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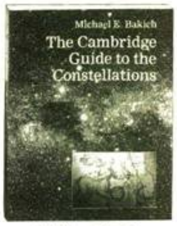
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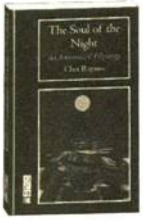
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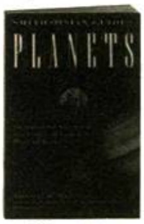
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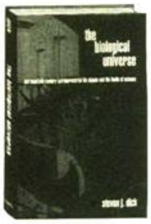
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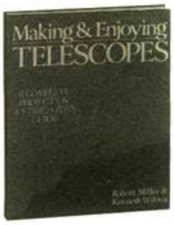
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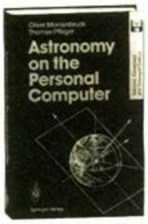
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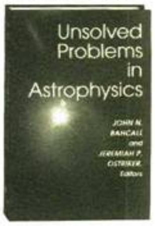
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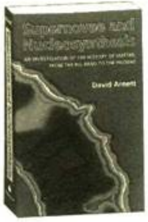
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NEWBRIDGE

ICE ON THE MOON?

Jury Still Out on Lunar Water

New evidence hints at dry moon

▶ Barely six months after a science team working with the Clementine spacecraft announced the possibility of ice at the moon's south pole, another group of scientists declared that their results show no trace of it. In the June 6, 1996, issue of *Science*, a group led by Cornell astronomer Donald Campbell details observations made with the Arecibo radio telescope in 1992. The team bounced radar signals off the moon to garner information about its surface. Similar radar studies of Mercury done in 1991 yielded echoes consistent with water ice in craters near the planet's pole.

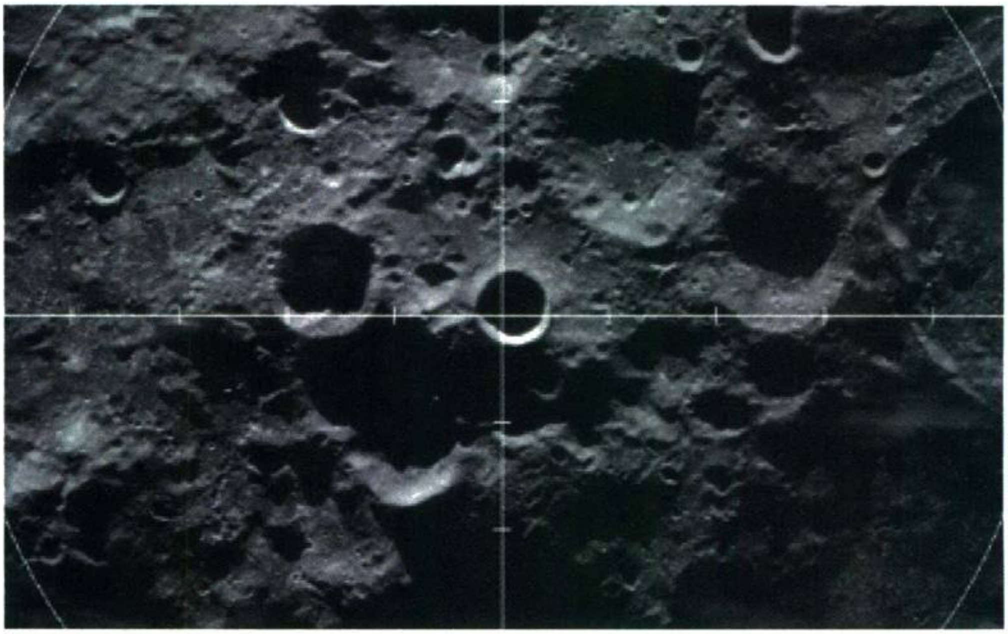
"We were hoping to see a similar situation for the moon, with unambiguous bright spots at the poles," Campbell said. "With Mercury it's pretty clear. But with the moon we didn't see anything like that."

Campbell's group did find many areas near the moon's poles and equator that reflected radar signals like ice-containing deposits would. But those spots were also bathed in sunlight. Water ice, they reasoned, would evaporate quickly in the sun's warmth, so the team attributed most of the "backscatter" they saw to the roughness of the surface.

This leads Clementine project scientist Paul Spudis to caution that how the data are interpreted is often just as important as what the data might suggest.

"We concluded in Clementine's case that because this response was seen in close association with zones of permanent darkness, it may be ice," he notes. "They conclude with the Arecibo data that because some coherent backscatter may not be in permanent darkness, it may be caused by surface roughness, not ice."

Spudis adds that both Arecibo and Clementine were looking only into zones of darkness visible from Earth. Neither study looked at the more promising areas of true permanent darkness, such as that in a six-mile-wide crater at the moon's south pole. So the whole issue of whether water lurks in the shadows near the moon's poles will have to wait until Lunar Prospector, with its water-detecting neutron spectrometer, launches in October 1997.



Cornell University News Service

The moon's south pole is laid bare in this image constructed from radar signals emitted by and reflected back to the Arecibo radio telescope in Puerto Rico. Scientists were hoping the signals would reveal unambiguous signs of water ice near the moon's south pole. They didn't.

HUBBLE VIEWS THE RED PLANET

The Changing Weather of Mars

▶ The current spacecraft "invasion" of Mars — Mars Pathfinder was scheduled to land on the planet on July 4 with Mars Global Surveyor arriving in September — will witness a decidedly different planet than the Viking spacecraft did in the 1970s. Thanks to observations made by the Hubble Space Telescope, astronomers know that Mars is now cloudier and colder than it was two decades ago.

"It's not the dusty Mars of the Project Viking days or the habitable oasis of science fiction stories," says Todd Clancy of the Space Science Institute in Boulder, Colorado. "The planet's weather apparently has a flip side to it." The two most important factors driving these changes are Mars's elliptical orbit and the strong interaction between airborne dust and water-ice clouds.

Images taken by the Viking orbiters showed huge dust storms that at times covered the entire planet. These storms arise when Mars is near perihelion (its closest point to the sun), when it

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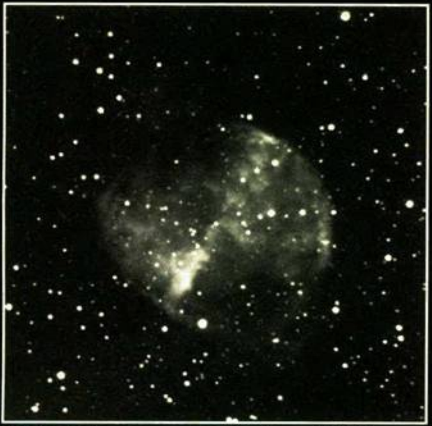
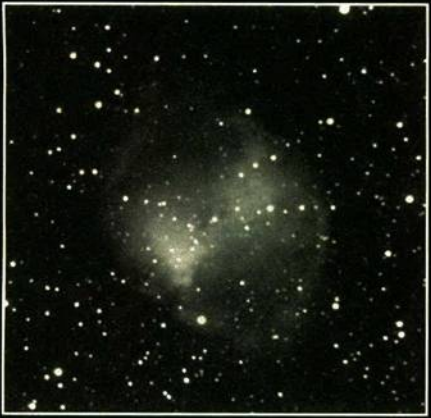
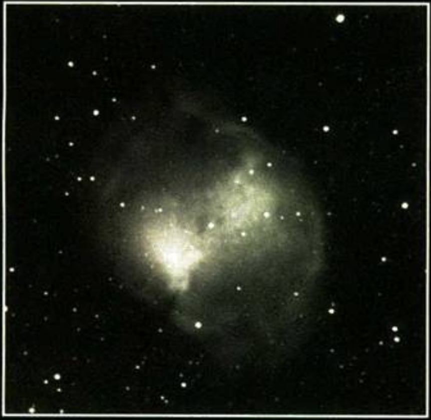


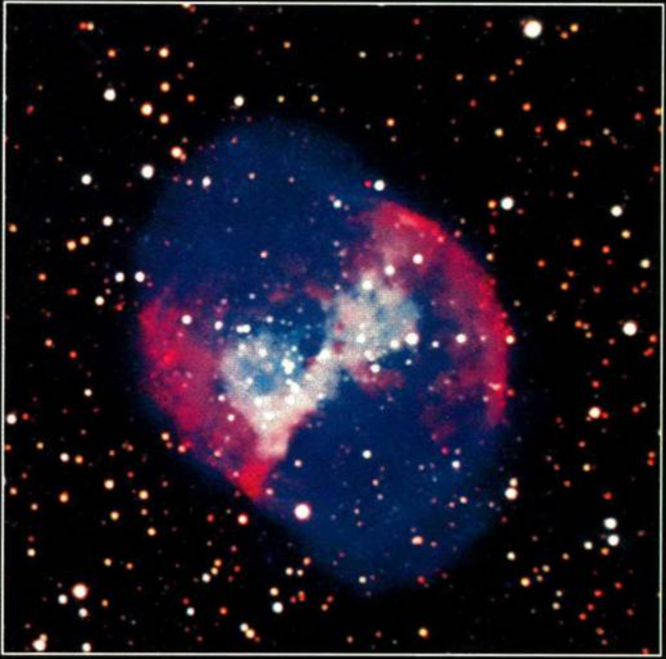
M27 Planetary Nebula. *1800 second exposure taken through a Red filter with the Model ST-7 CCD Imaging Camera and the CFW-8 Color Filter Wheel.*



M27 Planetary Nebula. *1800 second exposure taken through a Green filter with the Model ST-7 CCD Imaging Camera and the CFW-8 Color Filter Wheel*



M27 Planetary Nebula. *1800 second exposure taken through a Blue filter with the Model ST-7 CCD Imaging Camera and the CFW-8 Color Filter Wheel.*



M27 Planetary Nebula. As in all the planetary nebulae, the faint central star is an abnormally hot bluish dwarf with a spectrum resembling that of an ancient nova and a calculated surface temperature of about 85,000 degrees K., one of the hottest stars known. It is assumed that planetaries are formed by ejection of material from the hot central star, but the exact details of the process are unknown. Red, Green, and Blue Model ST-7 images were summed together and color balanced to create a true color image. *Courtesy of Benoit Schillings.*

Note: All images were processed from a computer disk to a standard photographic film using a Film Recorder. Courtesy of AstroPhoto, Oakview, California.

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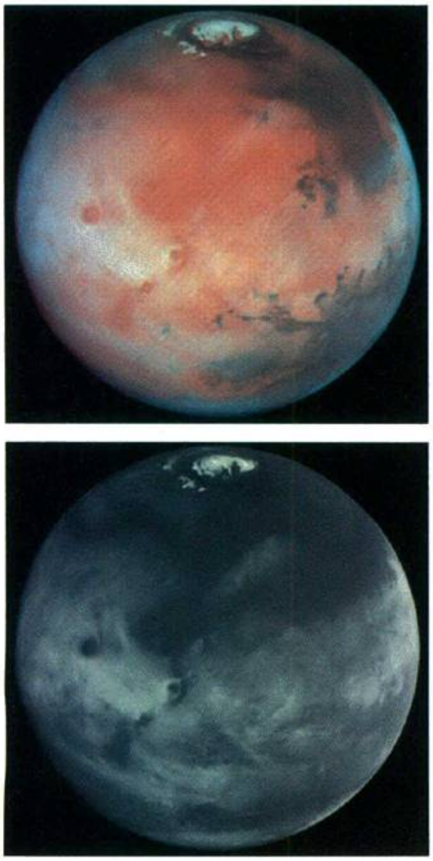
receives 40 percent more sunlight than at aphelion (its farthest point from the sun). The added heating drives strong winds that lift dust into the atmosphere, where it absorbs sunlight and raises the temperature even more. Surprisingly, these dusty conditions persisted throughout the Viking missions, even when Mars approached aphelion.

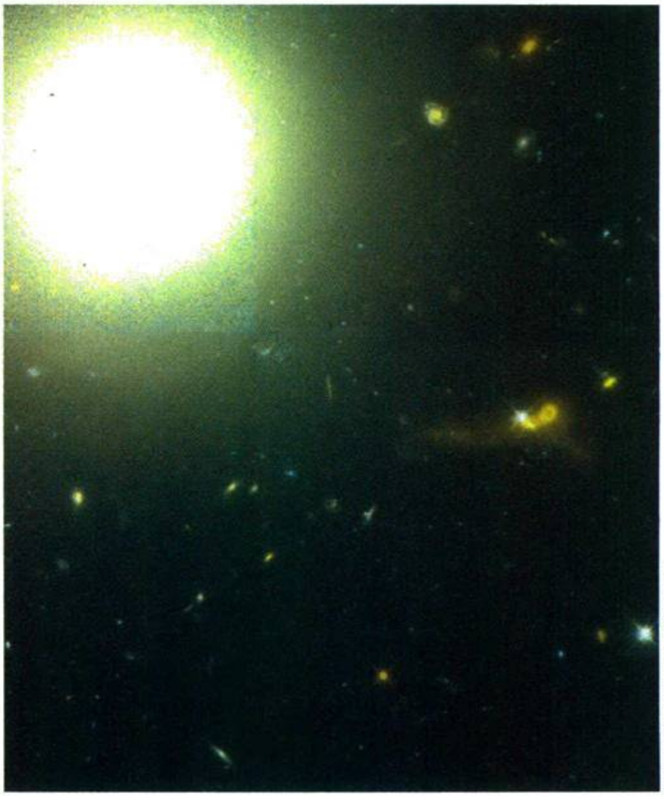
This anomalous weather meant the Vikings never saw the distinctive aphelion climate that now rules Mars. Water-ice clouds, which form in the cold atmosphere near aphelion, further reduce the temperature by forming around dust particles and causing them to settle out of the atmosphere.

Hubble will continue to monitor the Red Planet as Mars Global Surveyor approaches. To enter orbit, Surveyor will slow down by skimming the martian atmosphere in a complex aerobraking maneuver. Hubble is ideal for tracking any regional dust storms that could pose a threat by increasing atmospheric drag.



Hubble snapped Mars's portrait on March 30, two weeks after its closest approach to Earth. The color photo is a composite of images taken in red, green, and blue light. The black-and-white photo shows just the blue-light image and brings out details in the cloud structure. The four giant volcanos of the Tharsis bulge can be seen at the left of the images, while Valles Marineris stretches across the lower right.

Phil James (Univ. of Toledo), Todd Clancy (Space Science Institute), Steve Lee (Univ. of Colorado), and NASA



Hubble Space Telescope WFPC Team

Two new studies of the rich Coma Cluster of galaxies (part of which is seen here) yield a distance of 340 million light-years. When combined with the cluster's recessional velocity, this distance implies a Hubble constant of 68 kilometers per second per megaparsec.

HUBBLE CONSTANT

Yardstick to the Coma Cluster

▶ How fast is the universe expanding? To answer this question, astronomers need to measure both the distances and recessional velocities of galaxies. And they try to use galaxies as far away as possible so random galactic motions don't factor large in the calculation.

One of astronomers' favorite targets has been the large galaxy cluster in Coma Berenices. A group led by William Baum and Mark Hammergren of the University of Washington has compared globular clusters surrounding two Coma Cluster galaxies with globulars orbiting the Milky Way Galaxy, the Andromeda Galaxy, and the galaxy M87 in Virgo. All of these comparisons gave a consistent value for the distance to the Coma Cluster, about 340 million light-years.

An associated team, led by Bjarne Thomsen of Aarhus University in Denmark, found a similar result by comparing surface brightness fluctuations of one of the Coma galaxies with a much closer counterpart (M105 in Leo). When the cluster's velocity of recession of 7,200 kilometers per second is factored, this yields a Hubble constant (i.e. the expansion rate of the universe) of 68 kilometers per second per megaparsec — a value consistent with other recent measurements.

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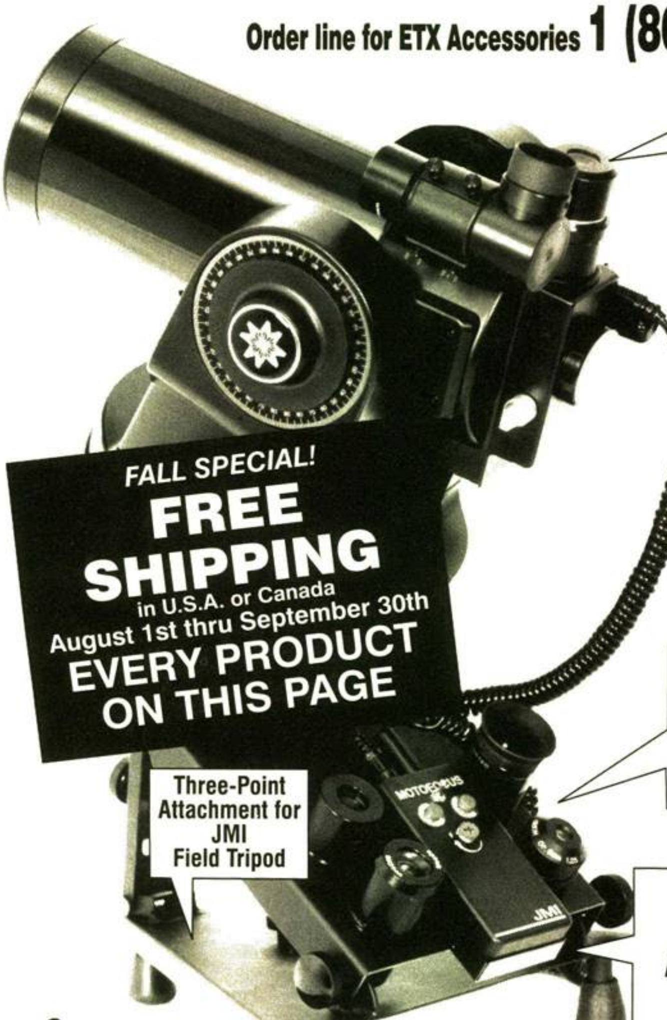

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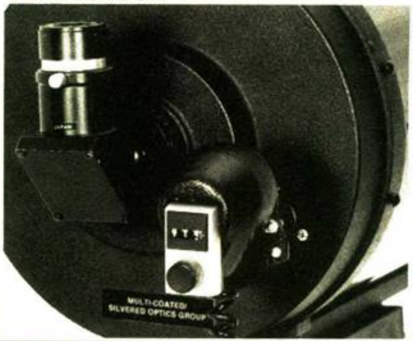

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Smallest Angle Measured

An international group of radio astronomers has measured the smallest angle in the history of astronomy: a trillionth of a degree. This is equivalent to the angular size of a large virus seen from the moon. The team, with astronomers hailing from the United States, Australia, and South Africa, was observing a 300-mile-wide region of radio emission surrounding the pulsar in the Vela supernova remnant, 1,600 light-years away. To achieve this phenomenal resolution, the team used ionized gas in the surrounding supernova remnant as a lens.

Distant Ellipticals Very Old

Elliptical galaxies have changed little in the last half of the universe's existence. That's the conclusion reached by Inger Jorgensen of the University of Texas at Austin and her colleagues, who have studied ellipticals in rich clusters. By looking at how the ratio between the mass and luminosity of the galaxies depends on the cluster's distance, they found that distant ellipticals are only a little brighter than nearby ones, confirming that the galaxies evolve slowly and that most of their stars formed when the universe was young.

Inger Jorgensen (Univ. of Texas at Austin)

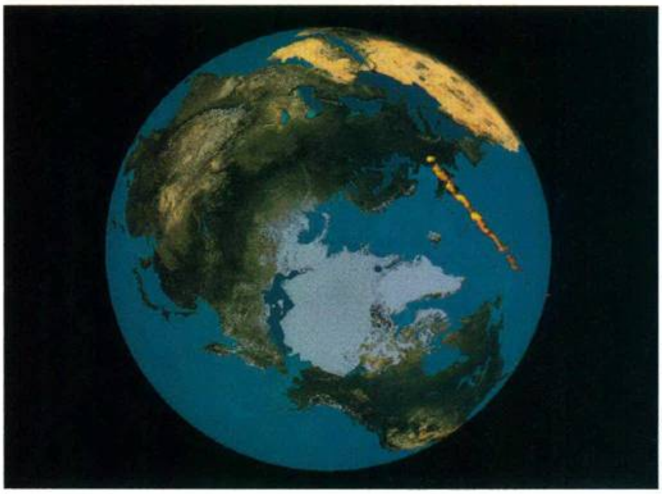
The rich cluster Abell 665 lies 3.7 billion light-years away.

Properties of the Youngest Stars

Thomas Greene of the University of Hawaii and Charles Lada of the Smithsonian Astrophysical Observatory have studied five protostars in Ophiuchus, each about 100,000 years old. The protostars rotated at an average speed of 26 kilometers per second (58,000 mph), about ten times faster than the sun and twice as fast as T Tauri stars. They spin fast presumably because they are still accumulating mass from surrounding disks. The astronomers also found the objects to have temperatures around 3500 kelvins. Over the next few million years, these protostars will contract into T Tauri stars, and in 50 million years become full-fledged stars.

Micrometeors from Solar System's Youth

Millions of incredibly old, small, and previously undetected invaders disintegrate in Earth's atmosphere every day. Using the sensitive radar system at Arecibo Observatory, John Mathews of Penn State found that the micrometeors continuously bombard Earth from all directions. "Most of them appear to originate on the edge of our solar system," says Mathews. "We think they are left over from the solar system's formation."



NASA/GSFC and the University of Iowa

NASA's Polar satellite imaged a mini-comet disintegrating 5,000 to 15,000 miles above the North Atlantic Ocean on September 26, 1996. The breakup was captured in far ultraviolet light; an image of Earth at the time of the event was superimposed for reference.

SPECIAL REPORT

Cosmic Rain of Mini-Comets

▶ In 1986 University of Iowa physicist Louis Frank announced to the world that a rain of mini-comets was bombarding Earth. Based on images from the Dynamics Explorer 1 satellite, Frank estimated that about 20 of these house-sized comets were slamming into Earth's upper atmosphere every minute. At the time, many scientists scoffed at Frank's conclusion, considering it to be impossible or ridiculous. Well, nobody's laughing anymore.

New images from NASA's Polar satellite, launched in February 1996, have all but confirmed Frank's discovery. The Polar images capture the signature of these mini-comets — dark spots in Earth's upper atmosphere caused by the breakup of the comets into diffuse water clouds — with much higher resolution than images from Dynamics Explorer 1. In addition, the new images show the mini-comets disintegrating 600 to 15,000 miles above Earth.

"Scientists I know, even skeptics, are now willing to grant the reality of these things, but they are still as skeptical as ever about the interpretation. On the other hand, no one has come up with an alternative," says atmospheric physicist Thomas Donahue of the University of Michigan.

"Everybody is extremely interested because if Frank is right, it has far ranging implications for all sorts of things," says Harvard planetary scientist Heinrich Holland. According to Frank, the mini-comets are fluffy, house-sized balls composed mostly of water-ice encased in a shell of organic compounds. Based on their estimated mass (20 to 40 tons each) and rate of impact (a staggering 7,200 to 40,000 per day, or 3 million to more than 10 million per year), they must be adding an inch of water to Earth's surface every 10,000 to 20,000 years. "If this has been going on

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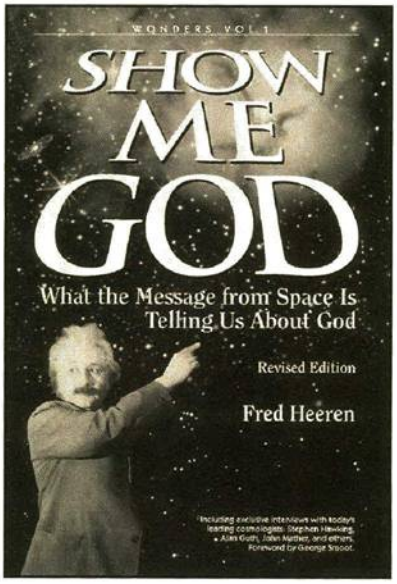
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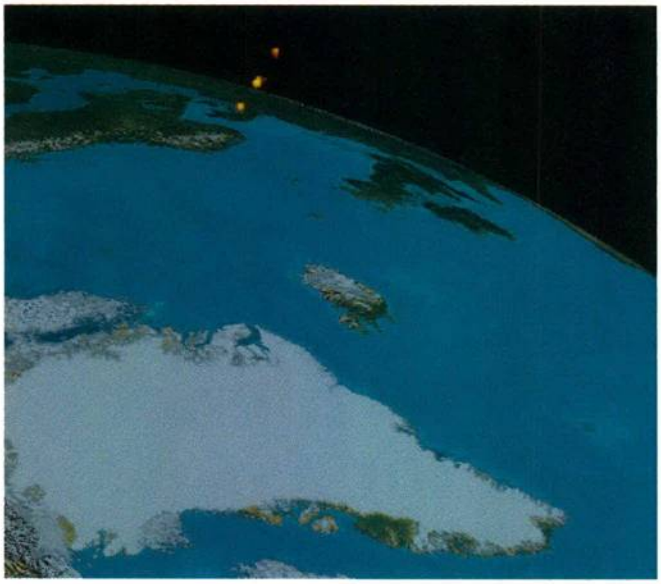


One of Polar's cameras records the movement of a water vapor cloud produced by the breakup of a mini-comet on December 31, 1996. The image consists of three 1-second exposures taken six seconds apart. The bright glow results from hydrogen atoms being stripped off water molecules. The water cloud is at an altitude of 2,000 miles; the image of Earth is superimposed.

NASA/GSFC and the University of Iowa

for 4 billion years, it would account for the water in our oceans," notes Frank.

Few scientists, however, accept this rate of infall. "Neither I nor anyone else I know believes that the amount of water involved can be within orders of magnitude of what Frank infers because it would have observable effects on Earth's upper atmosphere, on Mars, and in interplanetary space," says Donahue.

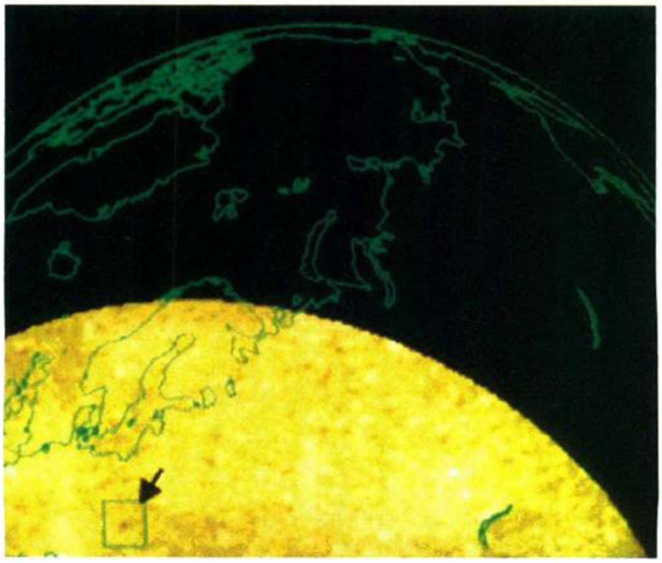
Whatever they are, the objects appear to be traveling at about 6 miles per second, which would give them enough orbital energy to venture as far out as Jupiter. Frank says these fluffy snowballs can't survive inside Earth's orbit because the sun's searing heat would vaporize the water. But in the space between Earth and Jupiter, there must be trillions of these objects. While their origin remains a mystery, Frank suspects they date back to the formation of the solar system 4.6 billion years ago.

These objects should be crashing into the moon and Mars as well as Earth, and they could be the source for the ice that was tentatively discovered on the moon last year. (Although new evidence from Arecibo questions that finding. See "Jury Still Out on Lunar Water," page 20.) Frank also speculates that the impact of these objects might be erasing the smallest craters on some of Jupiter's large satellites. "Other scientists in different fields will have to figure out how to accommodate them," says Frank.

Despite the frequency of impact, these objects pose no threat to spacecraft in low Earth orbit such as the space shuttle, Mir, or the planned international space station. The mini-comets are so loosely bound that tidal and magnetic forces tear them apart high above the altitude where these spacecraft orbit. However, a mini-comet impact would destroy any spacecraft above Earth's protective blanket. "A normal-sized spacecraft would get hit once every 10,000 or 20,000 years. That might not sound dangerous, but if we have 1,000 spacecraft up there, then every 10 years one of them ought to wink out, and some high altitude satellites have winked out," says Frank.

Despite the danger they pose to spacecraft, we can be thankful for these fluffy snowballs, for they may have delivered most of the water and organic matter that sustains life on Earth. Most of the water molecules in your body (which is 70 percent water) might have come from these mini-comets. In the time you have read this article, as many as 100 of these fluffy snowballs have hit Earth.

— Robert Naeye



When a mini-comet breaks apart, it forms a cloud of water vapor that temporarily absorbs light in Earth's upper atmosphere, forming an apparent 25- to 50-mile-wide "hole." The Dynamics Explorer 1 showed atmospheric holes as single pixels. The higher resolution Polar cameras, however, showed atmospheric holes as multiple pixels, proving the holes were for real and not the result of faulty data. Based on the rate that Polar detected these holes, University of Iowa physicist Louis Frank estimates that Earth is pelted by mini-comets 5 to 30 times per minute.

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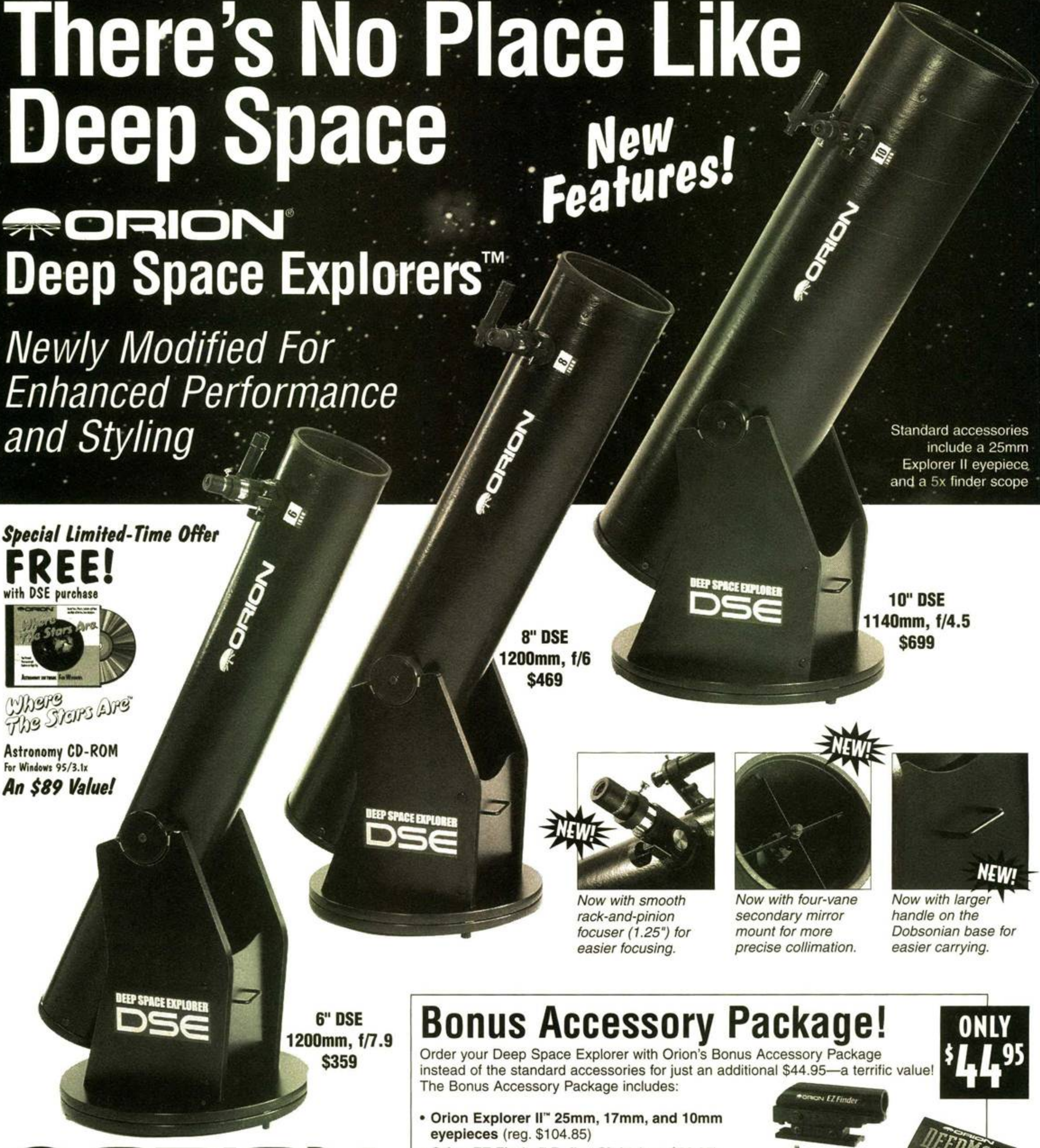

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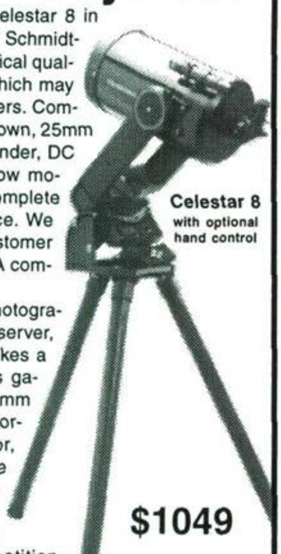

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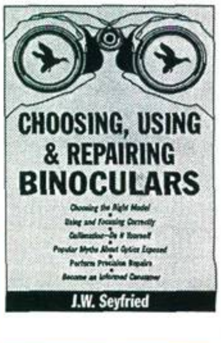

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WRITE NO. 75 ON THE READER SERVICE CARD

A Field Guide to UFOs

Planets, stars, fireballs, birds, and the moon — all have been commonly mistaken for extraterrestrial spacecraft.

by Philip J. Klass

DESPITE WIDESPREAD MEDIA COVERAGE OF UFOs (Unidentified Flying Objects), one important and well-demonstrated fact is seldom mentioned: At least 90 percent of all UFOs are really "Misidentified Prosaic Objects," or MPOs. More than one-third of all UFO reports are generated by bright planets, stars, meteor-fireballs, and even, occasionally, by the moon.

For example, the March 20, 1975, edition of the Yakima, Washington *Herald-Republic* carried a front page feature stating that three credible local citizens reported seeing a bright UFO in the western sky around 9 p.m. and watched it for about 45 minutes "until it disappeared." One man, who described the UFO as being cone-shaped with a "greenish-bluish light at the top and a sort of pale flame light at the bottom," said he had never seen anything like it before. Not surprisingly, the front-page story prompted other Yakima citizens to look for a UFO that night.

The next day's edition reported that many more persons had called in to report seeing the UFO, which had returned to the western sky that night at about the same time. The following day, the newspaper reported that its staff had been "swamped by calls by people mystified and convinced they were seeing an alien craft from outer space."

Fortuitously, one of the callers was an amateur astronomer who, after reading the two previous newspaper articles, had decided to take a look at the UFO. He reported it was the then bright planet Venus. Commendably, the *Herald-Republic* reported the UFO's identification on its front page, whereas many newspapers would have buried the explanation at the bottom of page 18.

There is scant scientifically credible data on the relationship between MPOs and UFOs. Since 1969, when the U.S. Air Force formally ended its 20-plus-year investigation of UFO reports and closed down its Project Blue Book office, nearly all of the people who now investigate UFO reports want to believe that some UFOs represent visitations by extraterrestrial spacecraft.

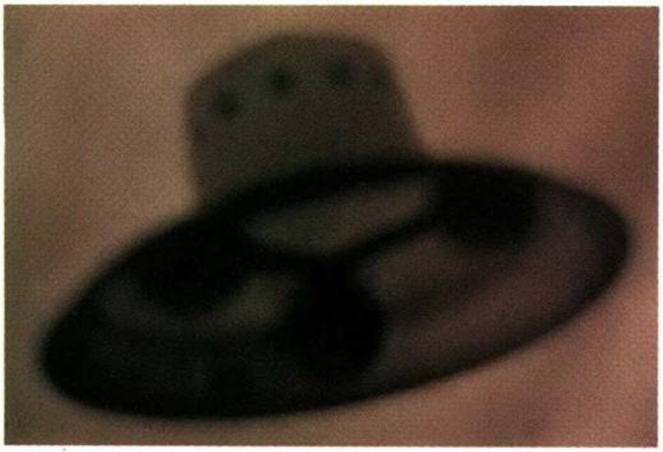
Despite many reports of UFO landings and persons who claim to have been abducted and taken aboard a flying saucer, no one has yet come up with a single credible physical artifact to confirm the ET hypothesis. The "physical evidence" found at alleged UFO landing sites typically consists of broken tree branches, or small holes that could be the work of wild animals, or a hoaxer. Not one of the many so-called "abductees" has come back with an ET souvenir or any new ET scientific information which could be verified to confirm their tale.

Because nearly half a century of UFO investigation has failed to yield a single, scientifically credible physical artifact, the only evidence supporting the ET hypothesis rests entirely on "unexplained" UFO cases. If an investigator is unable to find a prosaic explanation for a UFO report, believers in the ET hypothesis cite this as evidence that the UFO report was generated by an ET craft.

Because nearly all of the persons who now investigate UFO reports are eager to find "unexplainable" cases, this gives them scant incentive to conduct a rigorous investigation of a tough case. During my more than 30 years of investigating UFO reports, several cases required many months of part-time effort to find a prosaic explanation and one required more than two years.

A notable exception is the UFO investigative work of Allan Hendry, who became the chief investigator for the Center for UFO Studies (CUFOS), shortly after he graduated

Bill Mayer



Robert Sheaffer

To demonstrate how easy it is to fake UFO photos, UFO skeptic Robert Sheaffer created this flying saucer from a cottage cheese container and an aluminum plate.

from the University of Michigan in 1972 with a B.A. in astronomy and illustration. CUFOS had just been created by J. Allen Hynek, who then headed Northwestern University's astronomy department.

In the late 1940s, the Air Force hired Hynek as a consultant after it discovered that bright celestial bodies generated many UFO reports and that even experienced military pilots sometimes chased after a UFO that turned out to be a bright planet or star. At the time, Hynek was teaching astronomy at Ohio State University — not far from the Project Blue Book offices in Dayton. In 1969, when the Air Force decided to close down Project Blue Book, it terminated Hynek's contract. Several years later he created CUFOS and hired Hendry as its full-time UFO investigator.

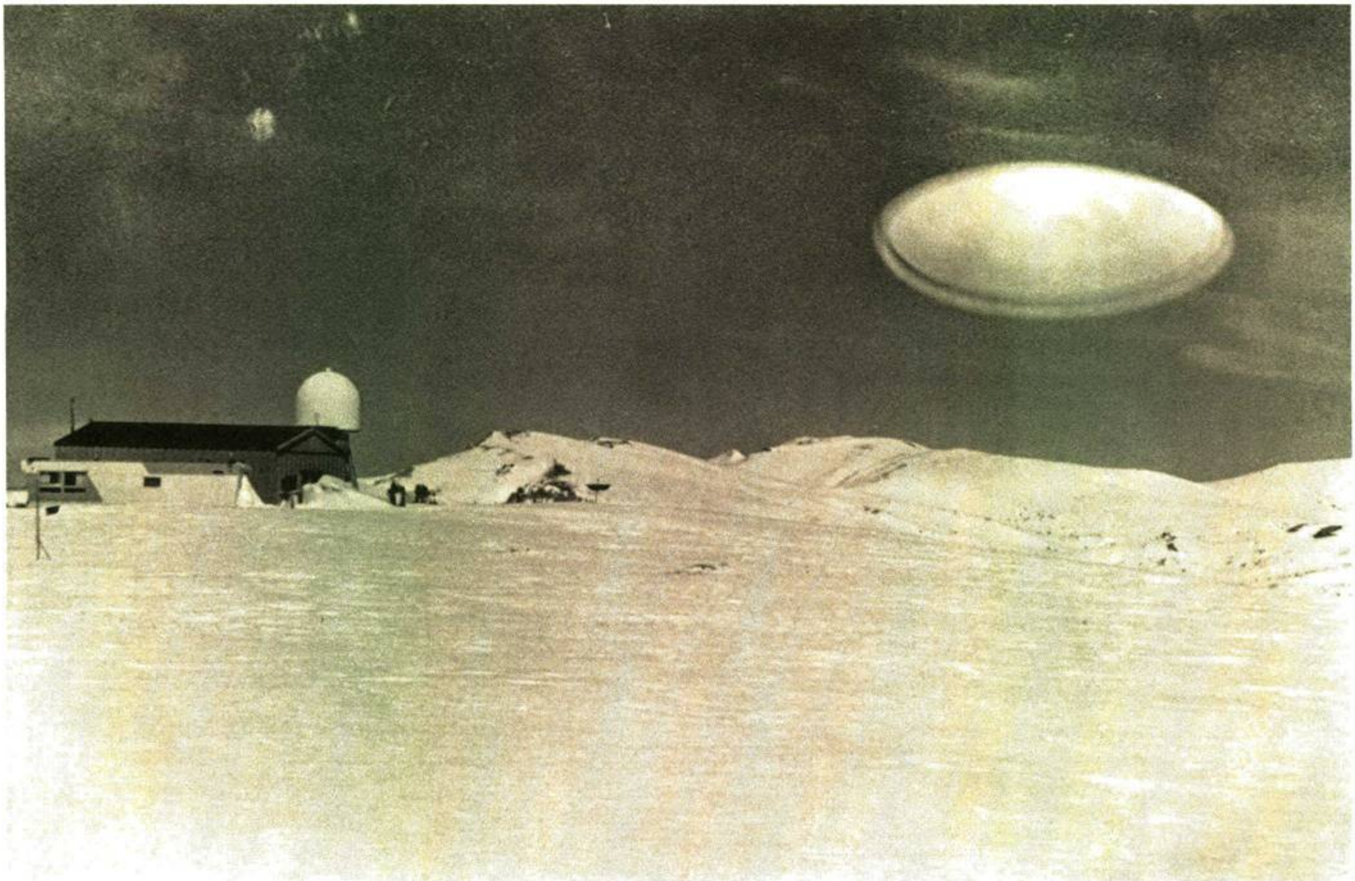
For Hendry, with a long-standing interest in UFOs, it was an exciting opportunity. Although Hynek had been a hard-nosed skeptic about the ET hypothesis when he was first hired by Project Blue Book, in his later years he became more "open-minded." He hoped that CUFOS could conduct a competent scientific investigation into the UFO mystery. To encourage UFO reports by law enforcement officers, who were considered to be more reliable than the general public, CUFOS obtained a toll-free 800 telephone line whose number was given to many police departments.

During the next 15 months, Hendry personally investigated 1,307 UFO reports submitted to CUFOS — many more cases than any other investigator up to that time, or since. The results were published in 1979 by Doubleday/Dolphin in a book entitled *The UFO Handbook: A Guide to Investigating, Evaluating and Reporting UFO Sightings.*

Hendry's book — regrettably long out of print — provides the most recent scientifically credible data on the many different "trigger mechanisms" which generate UFO reports. Earlier Project Blue Book data is criticized by some who charge that the Air Force's eagerness to explain away UFO reports resulted in

An alien spaceship on the horizon? Actually it's Venus, which is commonly mistaken for a UFO.

Wallace Baldwin



UPI/Corbis-Bettmann

Robert Rinker, a field technician at the Chalk Mountain weather station in Colorado, photographed this UFO in 1967. "Modern photo processing techniques make it so easy to fake UFO photos that older images such as this are much more convincing," says John P. Timmerman of the Center for UFO Studies.

unrealistic explanations. Hendry's data is not vulnerable to such charges because he admitted he would like to find evidence that some UFOs were ET craft.

Of the 1,307 UFO cases that Hendry investigated, he found prosaic explanations for 91.4 percent of them, leaving 113, or 8.6 percent, unexplained. However, Hendry conceded that 93 of these 113 unexplained reports had possible prosaic explanations. This left only 20 cases, or 1.5 percent of the total, as seemingly unexplainable in prosaic terms. Is that evidence that some or all of these 20 unexplained cases involved ET spacecraft?

Hendry wisely resisted making any such claim. In the closing pages of his book, he admitted that rigorous investigation alone is not always sufficient to find a prosaic explanation, which sometimes depends on "sheer luck." (Based on my own investigations over the past 30 years, I fully agree.) Another factor, which Hendry does not mention, is that with his other CUFOS duties, which included producing a monthly publication for subscribers, he could spend an average of only two hours in his investigation of each case. Some of the cases I have investigated have required many dozens or hundreds of hours of effort to find a prosaic explanation.

Early in my own career as a UFO investigator, I was "taken in" by several hoaxers who seemed at first to be honest. I suspect that at least several of Hendry's "unexplainable" cases are hoaxes and that he was too trusting, as I had been.

In the concluding pages of Hendry's book, he commented: "How can I be sure if my remaining 'UFOs' aren't simply Identified Flying Objects [i.e. Misidentified Prosaic Objects] misperceived (sincerely) to the point of fantasy? The emotional climate about the subject (as revealed by Identified Flying Objects) appears to be adequate to support such a hypothesis for a great many UFO situations, if not all . . . With our current inability to fully draw the distinction between real UFOs and IFOs, fantasies or hoaxes, coupled with a heated emotional atmosphere, I can only assert that it is my feeling that some UFO reports represent truly remarkable events." But Hendry admitted that "while science may be initiated by feelings, it cannot be based on them."

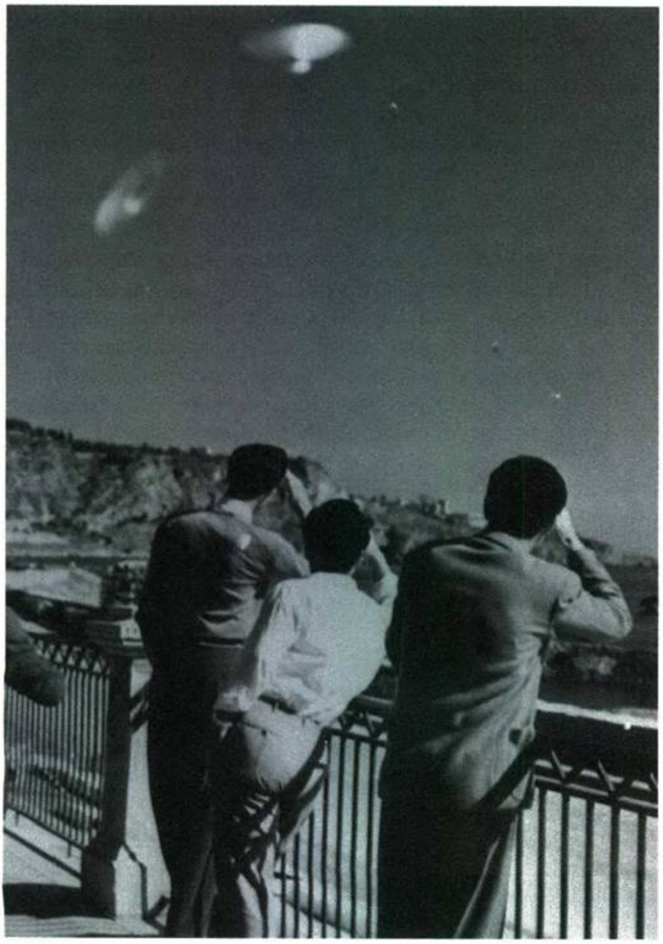
Hendry's investigation showed that nearly 28 percent of all UFO sightings reported to CUFOS proved to be bright stars and planets. Hendry noted that UFOs that turned out to be celestial bodies were often reported to "dart up and down," to "execute loops and figure eights." Occasionally the celestial UFO was reported to "meander in square patterns" or "zigzag." In 49 cases triggered by a bright celestial body, the witnesses estimated the UFO's distance at figures ranging from 200 feet to 125 miles.

When I first entered the UFO field, I would have challenged the idea that an intelligent person could mistake a bright celestial body for a UFO that was "following them." But numerous incidents, some involving law enforcement officers, have convinced me otherwise. If a person driving in a car sees a bright celestial object ahead and suspects that it might be a UFO, and accelerates to try to get closer, no matter how fast the driver goes, he/she cannot seem to gain on the UFO. If the driver then stops and gets out of the car, the "UFO" seems to halt also, because it is getting no bigger or smaller. Now, if the driver decides to return home, the "UFO" seems to be following the car because it remains the same size and brightness.

It might seem surprising that 22 of the UFO sightings reported to CUFOS turned out to be triggered by the moon. Early in my career as a UFO investigator, I was challenged to explain an incident that had occurred with a Navy aircraft crew on February 10, 1951, while en route from Iceland to Newfoundland. The Project Blue Book files listed the case as "unexplained." After careful study of the crew's report, many hours of investigation, and a bit of luck, this UFO could be identified as the upper tip of a crescent moon which was barely visible at the horizon.

Hendry's investigation showed that nearly 18 percent of all UFO reports were generated by advertising airplanes, which carry strings of lights that spell out an advertising message. When seen at an oblique angle, their strings of flashing lights are perceived as being saucer-shaped. When the pilot decides to turn off the lamps and go home, observers report that the "UFO mysteriously disappeared."

On June 5, 1969, the flight crews of two east-bound airliners flying above 30,000 feet near St. Louis, Missouri, as well as a military jet fighter pilot, reported a near mid-air collision with a "squadron" of hydroplane-shaped UFOs. The incident occurred around 6 p.m., in broad daylight. The military pilot reported that at the last minute the UFOs seemed to maneuver to avoid a collision — which could be interpreted as evidence that these objects were "under intelligent control."



ET visitors? Giuseppe Grasso photographed these flying saucers over Sicily in 1954. They remain unidentified.

UPI/Corbis-Bettmann

Roberto Boccadoro

An alien spaceship streaking through the atmosphere? Nope, it's a relatively bright yet run-of-the-mill fireball.

Thanks to Allan Harkrader, an alert newspaper photographer in Peoria, Illinois, who was able to take a photo of the UFOs, they could be easily identified as flaming fragments of a meteor-fireball blazing through the atmosphere on a horizontal trajectory. As a meteor enters at very high speed, it ionizes (electrifies) the surrounding air, creating a long, luminous tail. The two airline flight crews and the military pilot, understandably, assumed that the luminosity was the result of sunlight reflecting off metallic objects.

Based on Harkrader's photo and other reports from ground observers, scientists at the Smithsonian Astrophysical Observatory were able to calculate the approximate trajectory of the fireball. They concluded that the fireball actually passed about 125 miles north of St. Louis, at an altitude many thousands of feet higher than the two airliners and the jet fighter. The same fireball fragments were seen by a private pilot who had just landed in Cedar Rapids, Iowa. He filed a report on the incident with the Federal Aviation Administration's office in which he estimated the objects had flown directly over the airport's east-west runway at an altitude of only 1,000 feet. His distance estimate was in error by roughly 100 miles.

On March 3, 1968, at approximately 8:45 p.m., a group of three people in Nashville, Tennessee, saw what appeared to be a giant saucer-shaped UFO pass over them in eerie silence at an altitude estimated to be only 1,000 feet. In a detailed report later submitted to the Air Force, they reported seeing many rectangular windows, illuminated from inside the craft.

The Air Force also received a report of the same incident from a group of six people in Shoals, Indiana, 200 miles to the north. They described the UFO as being more cigar-shaped, with a rocket-like flame in the rear, but they too reported seeing rectangular windows, illuminated from inside. They reported it's altitude was "tree-top level."

This UFO proved to be the flaming reentry of a Soviet rocket that had been used to launch the Zond-4 spacecraft on a simulated lunar mission. As the rocket reentered at high speed, it broke into fragments which were heated to

CUFOS

A sheriff's deputy photographed this formation of UFOs over Connecticut in 1988. The Federal Aviation Administration identified the lights as low-flying private aircraft, although UFO proponents dispute this conclusion.

incandescence, which is what the observers in Nashville and Shoals saw. Once they concluded that this was a UFO, then the flaming fragments "became" windows illuminated from inside the craft. And their brains, unwittingly, supplied details of the craft's shape — based on what the observers had earlier read or heard about the shape of UFOs.

One of the universal characteristics of UFO reports generated by fireballs or reentering space debris is that the object always seems to be much closer than it actually is. In Hendry's book, he reported that nearly 9 percent of the 1,307 UFOs reported to CUFOS proved to be fireballs or reentering space debris.

Hendry, who retired from "UFOlogy" shortly after his book's publication and has never returned, discovered there are many, many trigger mechanisms for UFO reports besides bright planets, fireballs, reentering space debris, and the moon. These included hoax hot air balloons, weather and scientific balloons, missile launches, birds, and kites, to cite but a few.

Several years ago, shortly before I was to give a UFO lecture to the Seattle chapter of the Institute of Electrical and Electronics Engineers, I was standing outside the lecture hall chatting with several attendees. Suddenly, one of them pointed skyward and said, "What's that?" I looked up and there was a small, orange object which seemed to be hovering at an altitude of several thousand feet.

Someone said: "It looks like a kite." I responded: "No, it's much too high to be a kite, maybe it's a weather balloon reflecting the nearly setting sun." The other party responded: "It can't be a balloon, it's not moving." Suddenly, a third man spoke up: "I think I have some binoculars in my car," and he hurried to get them. He returned with the binoculars, took a brief look and said: "It's a kite." When I viewed the UFO through the binoculars, I agreed.

Were it not for the happenstance that this man had a set of binoculars, I would have to admit that I saw a "UFO" in Seattle that appeared to be too high to be a kite and too stationary to be a weather balloon. But it was not doing anything extraordinary — or extraterrestrial.

For 45 years I have been writing for *Aviation Week & Space Technology* magazine — for 34 years as one of its senior editors and since my "active-retirement" in 1986, as a contributing editor. The magazine has published more articles on space travel than any other publication in the world. I can think of no more exciting story it could publish, or that I could write, than to be able to report that I have finally found a UFO case that defies any possible prosaic explanation. I would expect to win a Pulitzer Prize, a giant bonus, and great fame. So far, I've had no luck. But who knows, perhaps tomorrow — or next week.

Leading UFO investigator Philip J. Klass is the author of UFOs: The Public Deceived, UFO Abductions: A Dangerous Game, *and two new books:* Bringing UFOs Down to Earth, *which is for children ages 9 and up, and* The REAL Roswell Crashed Saucer Coverup. *All of these books are published by Prometheus Books in Amherst, New York.*

When E.T. Calls Us

A message from an extraterrestrial civilization could truly shake the world.

by Seth Shostak

WITHOUT WARNING, A DRAMA of endless consequence could begin in the cramped, cluttered control room of a radio telescope in West Virginia. Here, where a hundred tons of steel face off against the pinpoint glints of the night sky, a back-burner experiment could change the world.

It would begin slowly, perhaps with a lone astronomer fighting to stay awake during the wee hours of the night. Seated in front of a bank of computer displays, she scribbles routine notes in a logbook. On the screens, blocks of text slowly update the status of the observations and monitor the electronics that are sifting through the cosmic static collected by the telescope. Occasionally, the astronomer looks up to read the displays' laconic reports. There are no high-tech sound effects and no theatrical music, only the constant drone of muffin fans in the electronic racks and the faint, distant grind of the telescope's tracking motor.

This is Project Phoenix, the most comprehensive search ever undertaken for intelligent company among the stars. Run by the SETI Institute of Mountain View, California, it is the privately funded descendant of a former NASA program. Here, at the National Radio Astronomy Observatory's 140-foot telescope in Green Bank, Project Phoenix scientists are systematically scrutinizing a thousand nearby sun-like stars for the faint signal that would betray intelligent habitation. So far, they have found nothing — not a single, extraterrestrial peep.

Keeping an ear to the sky, the 140-foot radio telescope in Green Bank, West Virginia, is searching a thousand sun-like stars looking for the faint signal that would indicate an extraterrestrial civilization. Seth Shostak

But tonight could be different. The observation of one star system has turned up an interesting signal. On the screen, a single line of text tells the tale, a string of numbers giving the signal strength and exact frequency, terminated by the cryptic words "confirmed by FUDD." At first blush, there is nothing special in this: With a receiver that simultaneously monitors 28 million channels plugged into one of the world's largest antennas, such signals are a routine event. In fact, the growing horde of telecommunications satellites that whirl above our heads have saturated the airwaves with signals that for all the world appear to be alien transmissions.

Project Phoenix has tried to inoculate itself against this noisome contamination by using a second antenna, the 30-meter Georgia Tech telescope located 50 miles south of Atlanta. The telescopes in West Virginia and Georgia check out promising signals with an automatic reobservation scheme orchestrated by a piece of digital hardware known as a Follow-Up Detection Device, or FUDD.

Now the FUDD has concluded that one channel out of 28 million bears the hallmarks of extraterrestrial origin. The solitary astronomer,

The Impact of a Detection

There's little doubt that a SETI success would precipitate intense scientific inquiry. But would it also provoke a dramatic response from society at large? Would there be panic? Disbelief? A sudden eruption of international goodwill?

The immediate reaction can probably be judged by the response that followed last summer's announcement of possible microfossils in a martian meteorite. There were two days of headlines, after which the discovery dropped off the public's radar screen. The story then became the province of long-timescale media such as books, documentary television, and magazines like *Astronomy*. There was no panic, and philosophical introspection was largely limited to newspaper op-ed columnists. Of course, the impact of the announcement of fossilized martian life was weakened by the uncertainty of the evidence. But the impact of a SETI success would also be compromised by the widespread belief that the aliens have long ago been sighted or overheard.

No matter how anemic the short-term reaction, most pundits assume that the long-term consequences of uncovering extraterrestrials will be profound. To get a handle on this, sociologists have often invoked historical analogs. The Copernican reorganization of astronomy and Darwin's revision of biology caused a "paradigm shift" in the perception of how humans fit in to the big picture of existence. We lost our central role in the physical and biological realms. Demonstrable proof by SETI that we have intelligent, cosmic company would surely deliver a roundhouse punch to any remaining hubris, such as the belief that we are intellectually, culturally, or morally superior. This is especially true because detecting one other technological society would presumably lead to the rapid discovery of more. We would find ourselves surrounded by advanced civilizations.

This could lead to a situation in which there's both good news and bad. The good news is the possibility that we can benefit from the knowledge and presumed wisdom of advanced beings. The bad news is that we might revert to a childlike mental state in which we assume that only our superiors can do anything that's really significant. Would an alchemist of the 12th century continue to toil in his laboratory if faced with the chemical knowledge of the 20th?

Seth Shostak

It may not look like something to write home about, but the straight line on the display screen heralds an intelligent signal. In this case, however,it is just a test signal of earthly origin.

Aside from science, there's the matter of beliefs. What effect would a SETI success have on religion? The answer is still vague. Michael Ashkenazi, of Israel's Ben Gurion University, made a study of a small number of religious authorities associated with the so-called "Adamist" religions — Christianity, Judaism, and Islam. Adamist religions share a story of man's creation, but also posit a special relationship between God and man. They hold that we are special. Consequently, extraterrestrial life might be expected to threaten that special relationship.

However, when Ashkenazi presented religious authorities with a scenario in which extraterrestrials have been discovered, "The most common response was amusement." The majority believes in E.T.'s existence, but none felt that this belief caused a problem for their religion. They said that it would be interesting to find the aliens, but their existence, and even their possible atheism, wouldn't affect earthly religions.

Given the historically severe reactions to both the Copernican and Darwinian revolutions, this restrained response might seem a bit *too* restrained. In fact, it may only reflect a failure to give the matter much thought. A hundred years of fictional aliens have misled us into thinking that we will understand E.T. The extraterrestrials in our stories are, for dramatic reasons, similar to us in motivation and intelligence (even if they often choose to emulate our destructive tendencies). They are not so "alien" that they can't be understood in the context of human experience. Consequently, the yet-to-be-discovered extraterrestrials that SETI seeks are seen as no more threat or challenge than someone from an obscure part of our own planet.

But as the English biologist J. B. S. Haldane said, "The universe is not only queerer than we suppose, it is queerer than we *can* suppose." His oft-cited remark applies admirably to modern astronomical research. We now catalog a host of cosmic objects — pulsars, quasars, and supernovae, for example — that were unimaginable a scant century ago. Those who expect the aliens, and their effect on humankind, to be less than extraordinary should take warning.

while taking note, does not get excited. After all, the system finds such candidate signals five or six times a week. Without prompting, the observing software swings the radio telescope two degrees away from the targeted star system. Several minutes go by, and the FUDD reports that the signal has disappeared, as would be expected if it came from the star system itself. The astronomer is paying close attention now, but her blood pressure remains unchanged. Satellites parading across the sky routinely move in and out of the antenna's sidelobes and can easily, if briefly, mimic extraterrestrial signals. Or perhaps the signal comes from a military jet whose pilot, by chance, has just switched off his radar.

The 140-foot scope slews back to the source. Ten minutes later, the FUDD reports that the signal has returned. The astronomer, her attention now riveted and her skin starting to tingle, waits as the telescope points to sky coordinates halfway between the on- and off-source positions. In another ten minutes she witnesses the next step in a staggering sequence of events, a sequence that has never before occurred. The insistent signal is still present, but at reduced intensity. Several hours later, the target star sets and the signal winks out on cue. Within a few days, and after enlisting the help of astronomers at another observatory, she will have observational proof that other thinking beings populate the galaxy.

Spreading the Word

How would the world react to such a discovery? Since 1989, a document has laid out what should be done in case of a SETI success — the "Declaration of Principles Concerning Activities Following the Detection of Extraterrestrial Intelligence." This short protocol with the long title has been adopted voluntarily by all SETI research groups. Thoroughly uncontroversial, the declaration describes procedures for verifying that the signal in question is truly extraterrestrial. These include, if possible, a confirming observation by a distant radio telescope (which minimizes the chance of a false alarm caused by fiendish interference, a bug in the system, or a sophisticated college prank). Once the discoverers are confident that the signal is truly not of this Earth, they are directed by the declaration to make their find public; to announce the startling result to the astronomical community, the authorities, and the world at large.

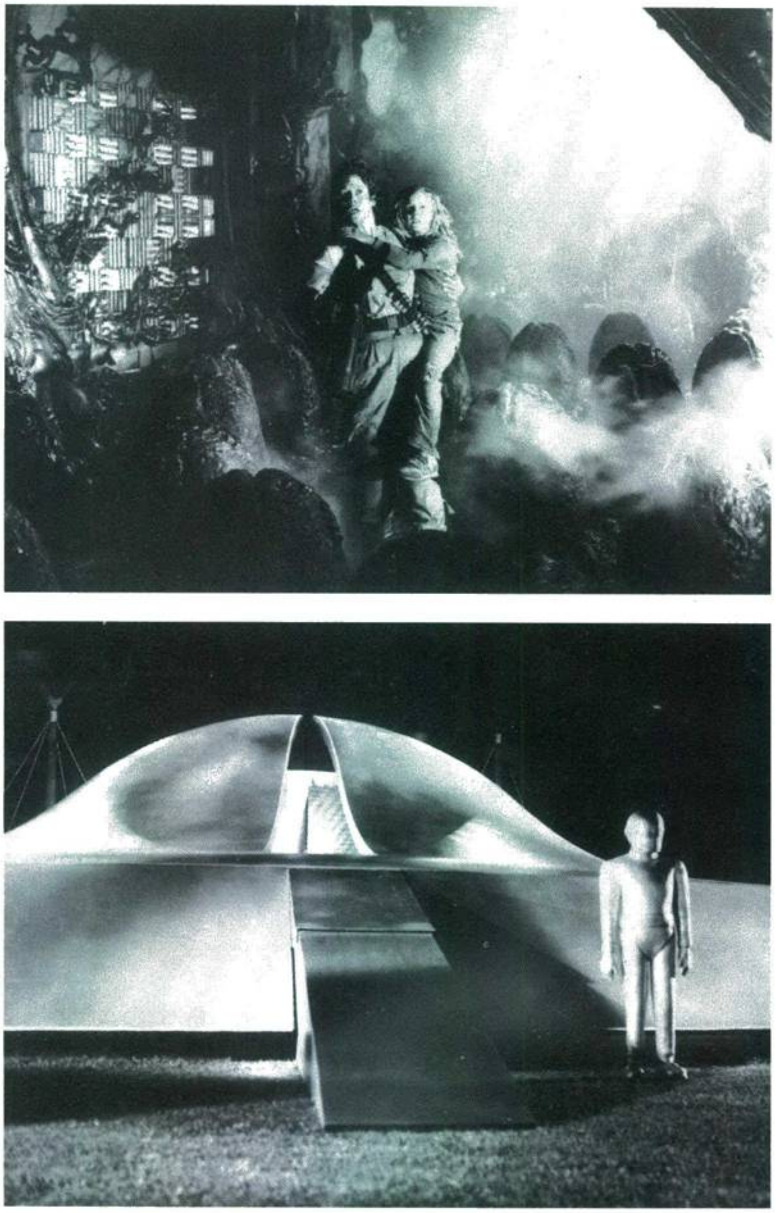
Fine. But recent polls show that the majority of Americans not only believe that extraterrestrials exist, but that they make house calls to our planet. According to the popular view, the government has hidden the evidence of aliens, and maybe even the aliens themselves. Extending these conspiratorial suspicions to SETI, many among the lay public expect that government agencies would swoop down on the radio observatories to protect the citizenry from the possibly dangerous news that extraterrestrials have been found.

Seth Shostak

Software developer Sally Page holds one of the dozens of circuit boards that make up the receiver used by Project Phoenix scientists to look for possible E.T. signals.

This is essentially impossible. To begin with, there is no policy of secrecy and no precautions to ensure it. Furthermore, by the time a detection is confirmed, a large number of people will be aware of the discovery (and some of these are likely to be at foreign observatories). Finally, the rapid and occasionally embarrassing spread of information about previous "close calls" shows that the tendency among researchers is to err on the side of bravado rather than caution. There is a far greater chance that an unconfirmed signal will be mistakenly reported as a detection than that a bona fide result will be covered up.

At the February 1996 meeting of the American Association for the Advancement of Science, a British reporter asked Dan Werthimer, a SETI researcher at the University of California, Berkeley, whether his team had investigated any of the star systems recently found to have planets. Werthimer responded in the affirmative that "yes, we have. The results were consistent with noise."



Friend or foe? Would any aliens we discover represent an aggressive species intent on destroying the human race or a benevolent society eager to impart its knowledge?

Springer/Corbis-Bettmann

This standard radio astronomer jargon was misinterpreted by the reporter, who assumed that "noise" meant "signal." A story soon appeared in a London paper that the aliens had been heard.

Indeed, if the leaks to the press that preceded the recent story about possible microfossils in a martian meteorite are a good example, the orderly sequence of detection, confirmation, and announcement outlined in the declaration is likely to be muddled. The Internet will be throbbing with rumors, and excited but incomplete reports will wash over radio and television.

In Contact

From this chaos, the facts of the detection will inevitably emerge. In view of the known technological limitations of SETI experiments, one can dare to predict what we would learn in those first, exciting days.

Although Project Phoenix's candidates are nearby (they are all star systems within 200 light-years of Earth), a simple detection by the 140-foot telescope would not prove that E.T.'s home was in orbit around the target star. After all, it's possible that, by lucky happenstance, a highly remote civilization was in the telescope's beam (which, at 1.4 gigahertz, covers a patch of sky about half the area of the full moon). But this uncertainty about the source of the signal could be quickly dispelled. Observations with the much larger Arecibo radio telescope, for example, would substantially narrow the field of sky from which the transmission came. Interferometers could resolve, both literally and figuratively, any remaining ambiguity in the source direction.

This would prompt optical astronomers to zero in on the aliens' star system and initiate a search for orbiting worlds that might prod their sun into a detectable wobble. Radio astronomers would be busy looking for slow variations in the frequency of the signal that would give a first indication of the spin and orbital parameters of the aliens' planetary home.

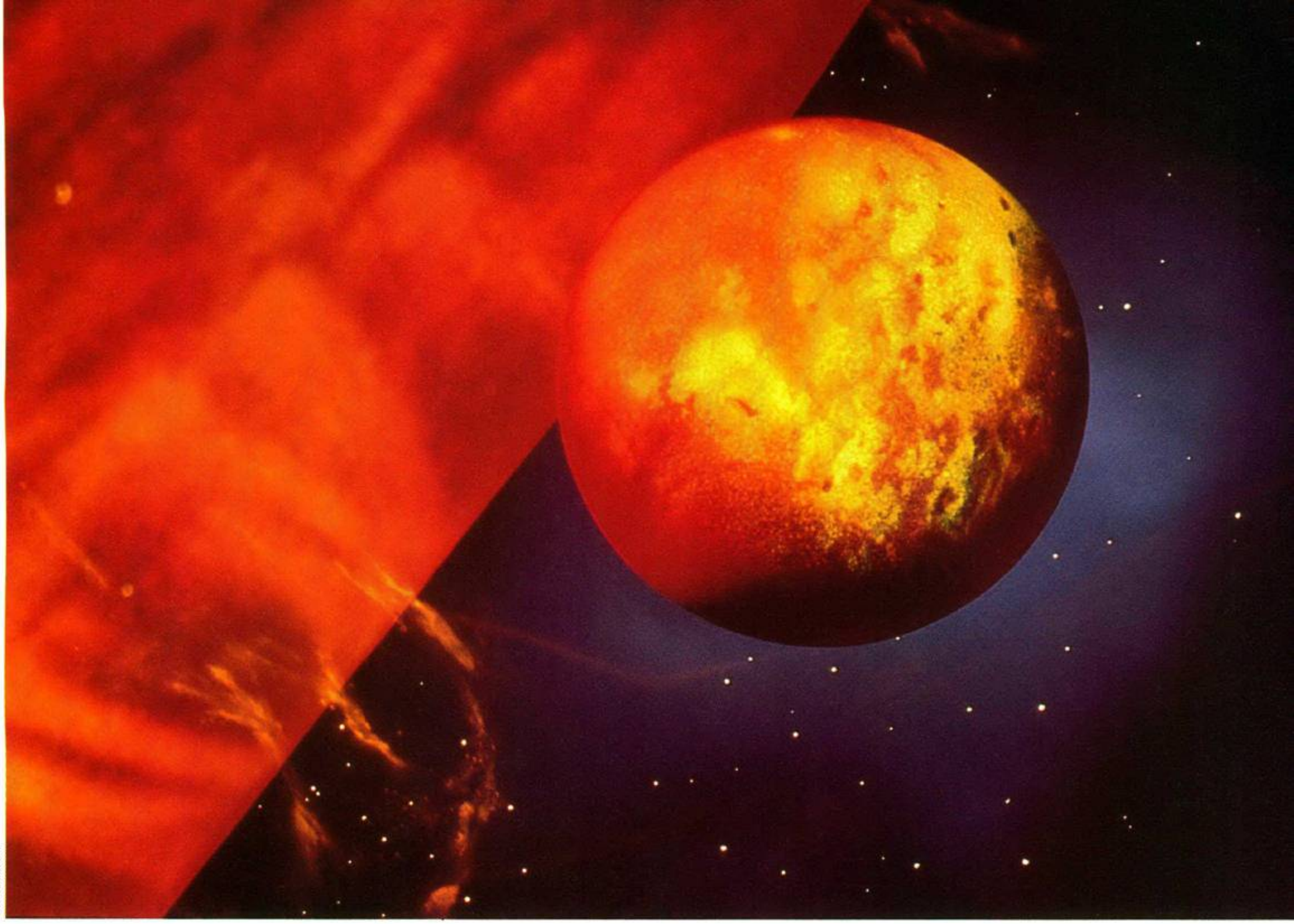
But what about the message? Wouldn't the SETI Institute's staff cryptographer leap into the breech to decode E.T.'s transmission? Alas, there is none. A popular misconception about SETI experiments is that they are intended to pick up actual messages, when in fact they are designed to find steady, or slowly pulsing, narrow-band signals that would pack a lot of energy into a small slice of the radio dial. The counterpart of this type of signal in earthly practice is the carrier wave that underpins most radio and television broadcasts. The carriers have the highest signal-to-noise of any part of a transmission, and would be thousands or millions of times easier to detect than the modulation, or message.

Does this mean that we would get the dial tone, but not the call? Not necessarily. Philip Morrison, the MIT physicist who was among the first to point out the possibility of interstellar communication by radio, thinks that a great deal of information might be packed into the transmission. According to Morrison, "We will be able to read the intention of the senders in the characteristics of the signal itself."

The fact that only slow variations could be easily detected is something that the extraterrestrials will foresee, says Morrison. Nonetheless, "They won't send an empty carrier. It will have a lot of structure, it will have clues, for after all it is the purpose of the transmission to inform us." One possibility is that the detected signal will simply tell us where on the dial we should go to find the real message. This presupposes that the signal was deliberately sent, but Morrison believes that we are more likely to pick up a powerful, intentional transmission than to stumble upon the aliens' internal radio traffic.

Talking Back

Deciphering any possible message might take a long time. Indeed, it might take forever. This



Seth Shostak

discouraging prospect derives from the argument that our chances of hearing a technological civilization are proportional to the average lifetime of such societies. If we do overhear someone, then we can expect that they are enormously more advanced than we are and probably far beyond our understanding.

However, while a SETI detection would mark *our* first contact with another galactic civilization, the same won't be true for those on the transmitting end. They will likely be an old society, one that has seen, and presumably dealt with, many other inhabited worlds. So once we make our existence known, perhaps the aliens will spoon-feed us by sending signals we can understand.

Such thoughts naturally raise the question of whether we should encourage such interplanetary pedagogy by letting the aliens know that we got their transmission. Broadcasting a reply may seem superfluous in light of the plethora of television and radar signals that have been streaming willy-nilly off Earth for half a century. But a directed response would be far stronger than this leakage, and presumably at a frequency the aliens will monitor. It might make sense to do this, if our intention is to join an interstellar chat group.

However, a deliberate reply raises some difficult political and social questions. Who will decide what to "say," or whether anything should be said at all? John Billingham, a SETI pioneer and scientist at the SETI Institute, is attempting to address this thorny, if hypothetical problem. He heads a committee of the International Academy of Astronautics that wishes to extend the declaration to treat the matter of deliberately transmitting to extraterrestrials. "Some people think that at this stage it's not worth indulging in such thinking," says Billingham. "But the significance of transmitting from Earth is potentially so profound in its implications for our civilization that we should consult extensively at the international level beforehand." The principles espoused by Billingham's committee are that any message sent to our cosmic neighbors should reflect the will and wisdom of all Earth's people.

Such diplomatic niceties may seem to be more science fiction than science. The protocols for establishing interstellar discourse are, after all, of no use today. We are, to our knowledge, still alone in a vast cosmos. But a single night's observing in the corrugated hills of West Virginia could change all of that. **A**

The possibility that other civilizations dot our galaxy received a boost in the last two years with the discovery of several extrasolar planets, like this one orbiting the star 51 Pegasi. Although no life has been found, at least scientists now know that the galaxy teems with planets, some of which could harbor extraterrestrials.

Seth Shostak is the public program scientist at the SETI Institute in Mountain View, California. His previous feature article for Astronomy *was "Listening for Life" in the October 1992 issue.*

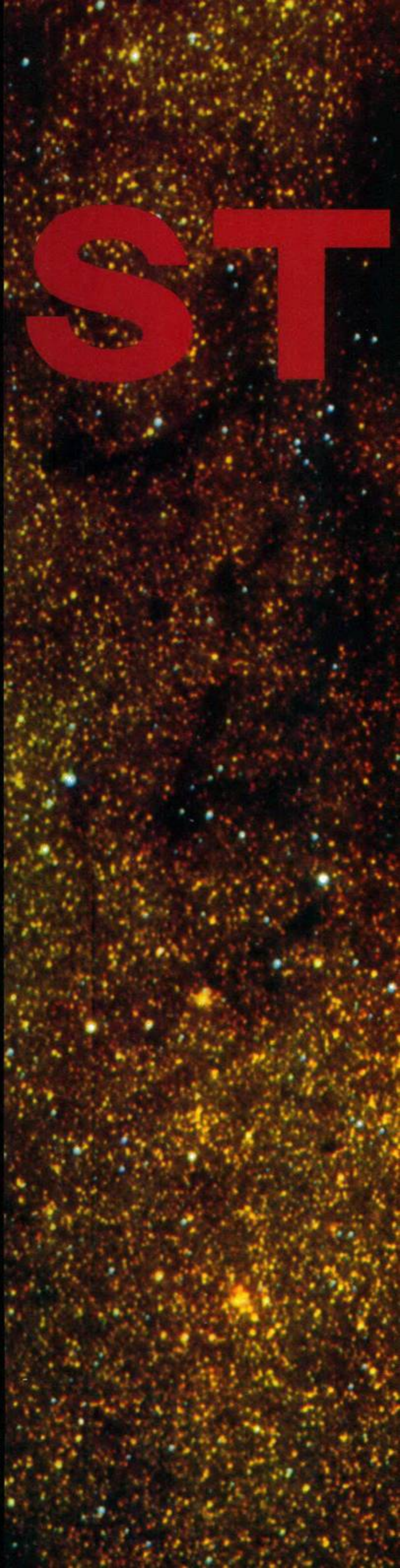
Does a MONST Lurk Closeby?

Making a case for a massive black hole at the heart of the Milky Way.

by Bonnie Schulkin

The dusty disk of the Milky Way Galaxy falls along our line of sight to the center, obscuring the brightness of the nucleus. Think about it: The constellation Sagittarius graces the foreground of the galactic center in the night sky, but at a glance, this region fails to advertise its uniqueness. To a casual observer, the Sagittarius Milky Way looks pretty much like the Milky Way in Cassiopeia or Canis Major. The same effect causes visible light from the galactic center to appear 30 magnitudes dimmer than if the dust weren't there — that's a factor of a trillion!

But all is not lost, thanks to the diversity of light in the electromagnetic spectrum. Even though visible light has trouble making it through the obstacle course of dust between us and the galactic center, other types of radiation are more successful. Picture the dust as a minefield, and the light as snakes winding back and forth among the mines. Snakes that make wide turns can maneuver around the mines; long wavelength radio and infrared radiation breezes through dust analogously. Snakes moving back and forth narrowly, in a relatively straight line, can fit between the mines — just as high-energy x rays or gamma rays penetrate dust grains by slipping in between their atoms.



Ian Gatley

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But visible and ultraviolet snakes have a terrible time getting through the minefield. Their curvy path is too wide to fit between the mines, but not wide enough to dodge them completely. Consequently, few of them make it past the minefield of dust from the galactic center to our eyes, leaving us with radio, infrared, x-ray and gamma-ray radiation as our sources of information about this region.

The minefield frustrates astronomers who want to answer one of astronomy's great questions: Does a massive black hole lie in the Milky Way's center? Such an object would swallow up matter around it with a voracious appetite — and the gobbled stars and gas clouds would never return. The existence of a central black hole could have significant implications for the future of our home galaxy. But the evidence for or against is not yet ironclad. To weigh the possibilities, we need to understand the journey astronomers have made in zeroing in on the galaxy's center.

The Galactic Center

Radio imaging of the galactic center has come a long way since Karl Jansky's pioneering observations in 1932. More and more detailed radio portraits have emerged with advancing technology, gradually revealing the two-part Sagittarius A complex. Sagittarius A East appears to be a supernova remnant, while Sagittarius A West contains a filamentary structure that has earned the nickname "the mini-spiral." Nestled within Sagittarius A West is a compact source known as Sgr A* (read saj-A-star), an object small enough to fit within 1/50 of an arcsecond in the sky. Not only is Sgr A* by far the most luminous radio point source in the galaxy, it also happens to coincide with the dynamical center of the Milky Way. Everything in the galaxy revolves around this radio source. Sgr A* is the point in the sky from which radiation must originate for an observation at any other wavelength to be associated with a central massive object.

Until recently it was difficult to determine whether or not an x-ray source coincided with Sgr A*. The x rays manage to overcome thousands of cubic light-years of galactic dust to reach Earth from the galactic center, only to be rebuffed at the last minute by molecular oxygen and nitrogen in our atmosphere. So scientists are limited to observing x rays with satellite telescopes, which have traditionally offered poor resolution. Several sources of x-ray emission have been found to populate the general vicinity of the Milky Way's center, but as Andreas Eckart of the Max-Planck-Institut für extraterrestrische Physik observes, "You can only say, okay, this x-ray source has to be in the galactic cluster, but you only know its position to, let's say, five or six arcseconds. And that's not good enough. It could be any other source in the galactic center."

Previous Page: Center of the Milky Way Galaxy at near infrared.

"Something really unusual is going on there — there's no doubt about that. It's like walking through a barren desert and stumbling across a Coke machine."

Images made with the Sigma/GRANAT telescope in 1994, however, provided resolution fine enough to conclude that there was no hard (high-energy) x-ray radiation source overlying Sgr A*. Recent data from another high-resolution telescope also failed to detect an x-ray source in the Sgr A* direction, even though the images did reveal a concentrated source offset from Sgr A*, emitting soft (low-energy) x rays. Future observations may tell a different story, but for the time being, the dynamical center of the galaxy seems conspicuously quiet in the x-ray region of the spectrum, in the midst of surrounding sources.

The neighborhood of the galactic center also shines brightly in the infrared, due to the massive, luminous stars found in the region. Such strong infrared sources are conspicuously rare in the sky. "You look around the galaxy with an infrared camera, and there's nothing else like it anywhere," explains Dan Gezari of NASA's Goddard Space Flight Center. "Something really unusual is going on there — there's no doubt about that. It's like walking through a barren desert and stumbling across a Coke machine."

Despite all this activity surrounding Sgr A*, however, it has been difficult to find an infrared source linked directly to the radio point source. A 1996 report of such an infrared observation caused a buzz of excitement in the astronomical community, but many scientists are hesitant to accept these results until they are confirmed by independent studies. They've seen reports like this before. New techniques offering better resolution or different interpretations of the same infrared sky have spawned many a rise and fall in hopes for an infrared source at the center of the Milky Way, and few definite conclusions remain once the dust settles. Still, there's hope for the future. The NICMOS infrared instrument recently installed on the Hubble Space Telescope will surely help to clarify the ever-evolving infrared view of the galactic center.

All of these measurements at different wavelengths contribute pieces to the galactic center puzzle. Astronomers can approach observations in another way, however: They can examine the movement of the stars in the region. Why is this useful? Well, just as the mass of the sun can be determined by the rate at which its planets orbit, the frenzied orbits of stars and gas near the galactic center can reveal the central object's gravitational power. Until recently, only radial motions of the stars in the region had been measured; that is, astronomers only knew how fast the stars were moving toward or away

Looking Toward a Black Hole

From the backyard, it's impossible to see the massive black hole that probably resides in the Milky Way's center. The monster lies some 27,000 light-years away from the sun, shrouded by layers of spiral arms and vast clouds of dust. But observers equipped with just binoculars can zoom in on the location that marks the center of the galaxy, and it lies in a familiar area of sky.

The galactic center, marked on star charts as 0° galactic longitude, lies in Sagittarius about 3° north-northeast of the bright open cluster M6 in Scorpius. Roughly speaking, it's between M6 and the famous Lagoon Nebula (M8). It lies just over 1° southwest of the 5th-magnitude variable star X Sagittarii.

So the next time you're out under a summer sky, take a moment to gaze at this splashy starfield in the southwestern corner of the Sagittarius Milky Way. You won't see the monster that dwells in the heart of our galaxy, but there's something special nonetheless about knowing it's there, lurking in the background.

— Dave Eicher

David Lee and Jason Ware

from Earth. Proper motions — motions back and forth along the plane of the sky — could only be inferred. Measuring the stars' total speed from this limited information is like trying to determine the speed of an airplane but only knowing how fast its altitude is changing. The plane could be zooming forward, but staying a constant distance from Earth; as far as your measurements were concerned, it would look like the plane was standing still. In the same way, a mass estimate based on the velocities of stars is only as strong as the assumptions made about the proper motions.

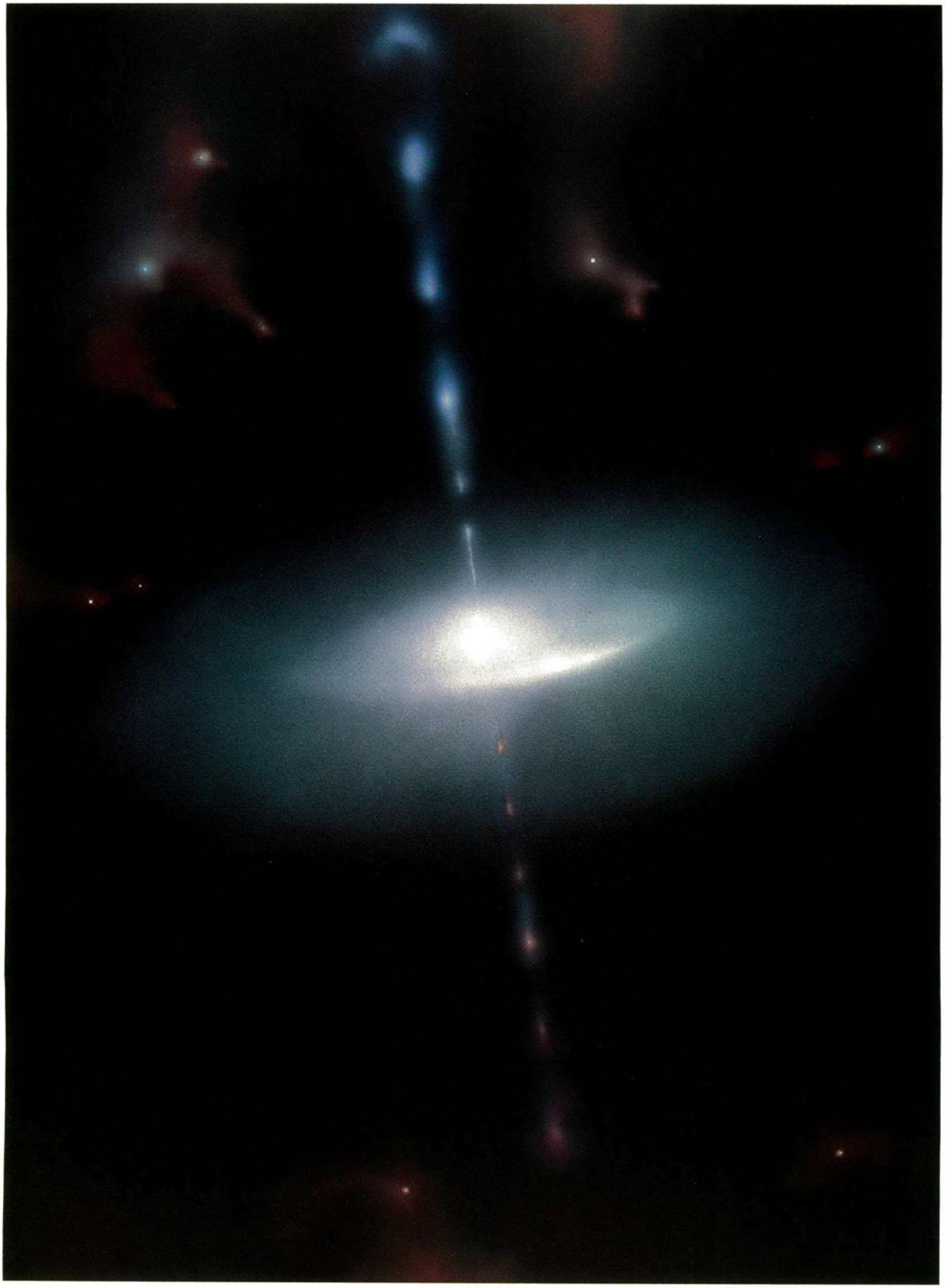
Confirming proper motions with observations is long and tedious work. In fact, the measurements of Eckart and his colleague at the Max-Planck-Institut, Reinhard Genzel, spanned five years of tracking stars. But their efforts paid off. They confirmed the accuracy of assumptions made in previous arguments about proper motions. There does indeed appear to be a compact mass of two to three million times the mass of our sun in the center of the Milky Way Galaxy.

This dynamical evidence argues unquestionably for an extremely compact object. The proper motions study confirmed the galactic center's formidable mass and small volume. Surprisingly enough, however, the mass density calculated from these values would be far less than that of ordinary water. In order to infer an actual density for the black hole, astronomers need to consider that galaxies consist mostly of sparse gas or empty space, with their mass concentrated into knots of matter as stars or stellar remnants. So on a galactic density scale, we're seeing something truly remarkable here. "The density that you can derive," asserts Eckart, "is the largest value, basically, that has ever been measured for nuclei of galaxies."

Within the bounds of modern theory, this makes the mass at the center of the galaxy far too dense to be anything but a black hole. According to Genzel, "There is no existing model in astronomy that would cause a concentration of material of any kind to be stable over any longer than a hundred thousand years or so, and that's so short that you must form a black hole. Now while we can state this, there could be someone who could say, 'Well, maybe there's another configuration — you just don't understand this.'" In other words, no one knows of any object other than a black hole that fits the clues offered by the center of the galaxy. But that doesn't mean no such object exists.

Now there's still a possibility that the two to three million solar masses describes not one large black hole, but many smaller black holes — each maybe five or ten solar masses. "And that's not completely crazy," declares Mark Morris of UCLA, "because massive stars are forming in and near the center of the galaxy. It's possible for enough stars to have formed over the lifetime of the galaxy for there to be a substantial cluster of these remnants of stars." Since theory predicts that massive stars become black holes once their fusion ceases, the stars at the center of the galaxy could have left behind a gang of black holes large enough to explain the dynamical evidence.

But a gang of small black holes fails to resolve one crucial problem, namely the relative lack of radiation coming from the galactic center. Contrary to what their name implies, black holes should shine brilliantly. Their gravity attracts surrounding matter, which swirls around the black hole in an accretion disk before falling in. Before being engulfed, however, the matter sends out a sort of S.O.S. "If you take a certain amount of mass and drop it into the black hole, it has a certain amount of rest energy," explains Ramesh Narayan of the Harvard-Smithsonian Center for Astrophysics. "About 10 percent of that, we believe, ought to come out as radiation." In other words, the amount of radiation generated by the black hole depends directly on how much mass it is in the process of accumulating. But when you



Mark Paternostro

take a look at the radiation from the galactic center and compare it to widely held predictions based on how much mass should be falling into a theoretical central black hole, there turns out to be a discrepancy by a factor of a few thousand. This presents quite a problem. Still, it isn't enough to shake the faith of avid black hole proponents. According to Genzel, resolving the evidence for a large, compact mass with the low observed luminosity "is basically a theoretical challenge now."

Narayan and his collaborators, Insu Yi and Rohan Mahadevan, provide a model to tackle this challenge. They theorize that conditions near the galactic center make it difficult for gas to cool off. Narayan explains, "What happens is the black hole just swallows this energy. When the gas falls in, it falls in along with its heat. The whole thing disappears into the black hole. This is one of the things we like about this model — that we explain the lack of luminosity, but we make that explanation work by using something very fundamental about black holes." Any other kind of exotic matter would not suffice for this scenario; nothing but a black hole can devour radiation.

There are other explanations for the low luminosity, too. For one thing, you'll recall that the amount of luminosity we see depends heavily on how much mass is falling onto the black hole. And not everyone agrees on how much mass this should be. Morris asserts, "There's no problem in coming up with models that give the low emission that seems to be the case for a central black hole — in terms of just a low mass-accretion rate." The amount of emission itself isn't even well understood. In addition to the observational controversies described above, Eckart points out, "One doesn't really know the actual luminosity of Sgr A* at any wavelength other than the infrared, where we know its position, and the radio." So uncertainties about influx and output make for a difficult inventory of the galactic center, and conclusions about mass accretion versus radiation will vary with the observer.

Let's assume for a moment now that the nucleus of the Milky Way does indeed house a massive black hole. Would this make the Milky Way unique among the galaxies of the universe? Probably not. Galaxies such as M31, M87, and the Sombrero Galaxy are all sufficiently close for us to examine the traffic patterns of their central regions. These galaxies are distant enough, however, that their nuclei are not monitored easily. They make the observations at the center of our galaxy seem simple by comparison. Nonetheless, the dynamics near the nuclei have been observed, and there is evidence for black holes on the order of a million to a billion times the mass of our sun in many nearby galaxies.

Artist's rendition of black hole at the center of our galaxy, shown with accretion disk and spewing jets.

There's still a possibility that the two to three million solar masses describe not one large black hole, but many smaller black holes — each maybe five or ten solar masses.

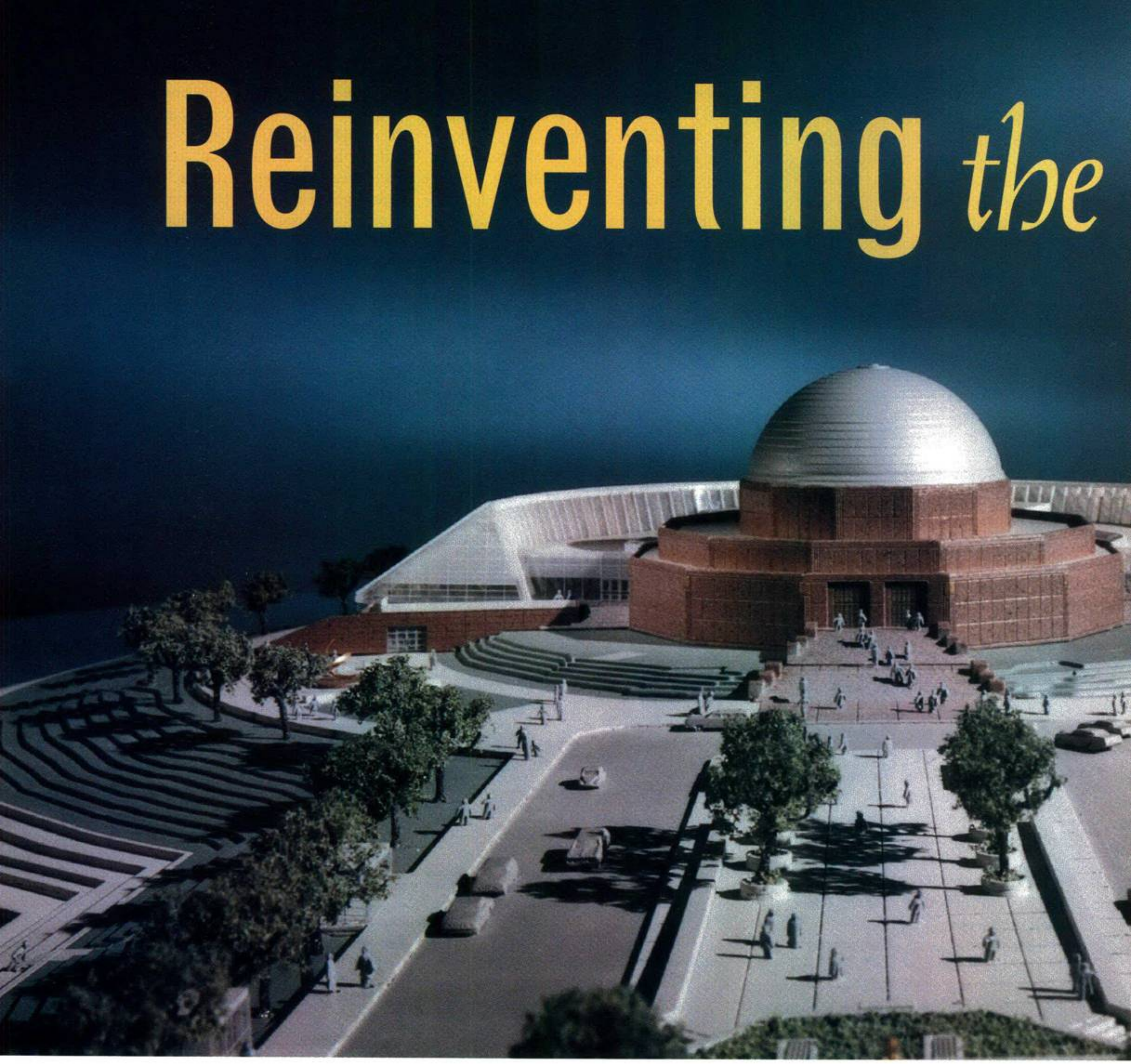
More distant galaxies can reveal potential central black holes in other ways. Astronomers have observed highly luminous galaxies — so-called "active galaxies" — whose energy could plausibly be generated by enormous central black holes a million to a billion times the mass of the sun. According to the spectral fingerprint of active galaxy emission, much of the radiation can't come from starshine. Furthermore, the light is sometimes accompanied by gigantic jets of matter traveling at relativistic speeds away from the nucleus, as if aware of a monster lurking there. The radiation and jets provide enough energy output to reach us across billions of light-years from quasars, the most distant of these active galaxies. But some active galaxies — albeit calmer than quasars — also exist closer to home, as close as ten million light-years away. For comparison, consider that we live roughly two million light-years from the Andromeda Galaxy, our closest major neighbor.

Could our own Milky Way once have been an active galaxy? Morris believes so. "All the elements you need for activity are there," he notes. "What do you need? You need the black hole, and the gas to fall onto it in a cataclysmic event. That's probably what happened about five or ten million years ago, when the existing cluster of massive stars was formed." Turning the clock the other way could result in an active Milky Way Galaxy in the future. Genzel describes one possible scenario: "A star would be spiraling in, and it would form an accretion-disk-like structure around the black hole, and then produce for a few years — maybe ten years, maybe a hundred years — enormously bright emission, and that would be an active galactic nucleus."

At present only a snapshot of galactic center theory and observations exists. More sophisticated observatories and techniques are providing images of the region in unprecedented detail, and there's no shortage of scientists whose curiosity leads them to conduct studies. Whether or not there is a black hole in the Milky Way's center, whether or not the galaxy was or ever will be an active galaxy, you can look forward to reading more about in the future. And perhaps someday you'll even open *Astronomy* to an article titled "Case Closed for the Milky Way's Giant Black Hole."

Bonnie Schulkin, a recent graduate of Williams College, wishes to thank Deb and Jeff Goldader for their help with this article.

Reinventing *the*



It's your first trip to the planetarium and you'll probably never forget it. The house lights dim as the sun sets in the west. The songs of birds gradually give way to the sound of crickets chirping on a hot, still summer evening. Soon, with the barely audible clicking and whirring of an ungainly, glowing contraption in the center of the room, a brilliant star field lights up the domed ceiling above you. The hour of wonder has begun.

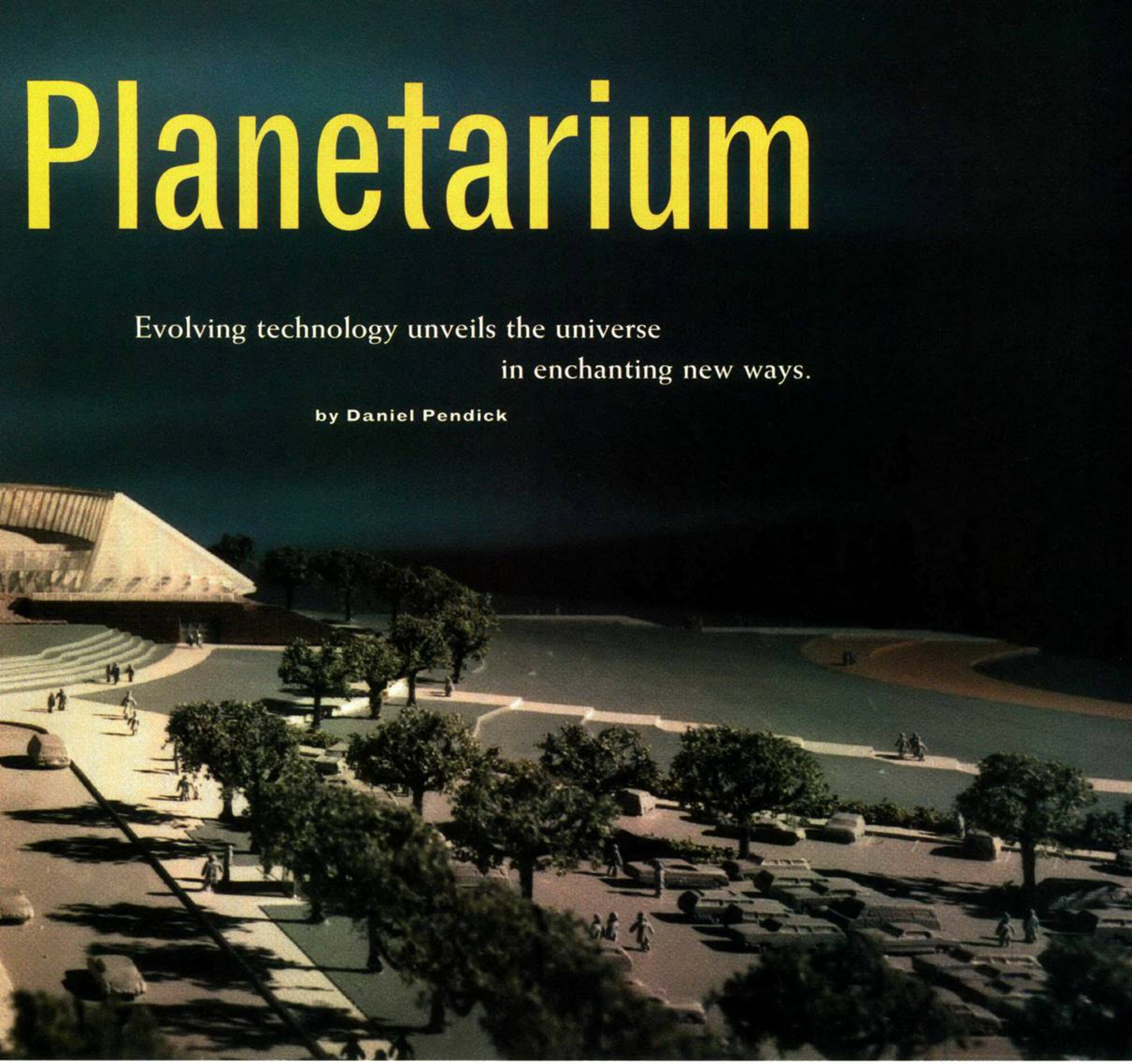
Future generations may remember things differently. In North America, home to more than half of the world's sky theaters, several historic planetariums are in the midst of major renovations and at least a half dozen new science centers are on the way. All are adopting the latest technology; a handful are taking the first steps toward what some believe is the planetarium of the future: a fully immersive visual environment where banks of video projectors and powerful graphics computers take audiences on journeys from the macrocosmos of space to the microcosmos of the atom.

Those who cut their teeth on traditional sky shows may find the new planetarium a bit unsettling. Already, the glowing "star ball" of old is competing head-to-head with Martin, a computer-based system that projects the sky through a single fisheye lens. And the stars themselves have begun to compete for space on the dome with biological cells, fractal landscapes, and even St. Peter's Cathedral. Both the medium and the message of

Planetarium

Evolving technology unveils the universe
in enchanting new ways.

by Daniel Pendick



the planetarium are changing, and in decades to come the only thing left of today's planetarium may be the seats and the domed ceiling. In fact, many won't even be called planetaria.

Making the Stars Dance

In the present-day planetarium, the defining piece of hardware is still the central star machine. With its motors, gears, and axles, analog projectors re-create the night sky and its motions as well as the movements of the sun and moon. Special effects projectors spice up the sky with meteor trails, lightning bolts, black holes, and other celestial staples. There are 2,561 planetaria in the world today, says Loch Ness Productions president Mark Peterson, who produces planetaria materials including shows and music. He says the overwhelming majority of them still use analog technology. But that is changing.

The planetarium world took its first step away from motors and gears a decade ago, when Evans & Sutherland of Salt Lake City introduced the Digistar projector. Digistar's computer draws the night sky on a very bright video tube whose light is then projected onto the planetarium's domed ceiling through a fisheye lens. Digistar can project any image that can be rendered as a series of points and can fly the audience right into its database of stars.

"One of the real strengths of Digistar is its ability to make the universe truly three-dimensional,"

With a commanding view of Lake Michigan, the Adler Planetarium and Astronomy Museum will receive a $40-million facelift to become one of the most technically advanced planetaria in the world.

James Steinkamp —
Steinkamp/Ballogg Chicago

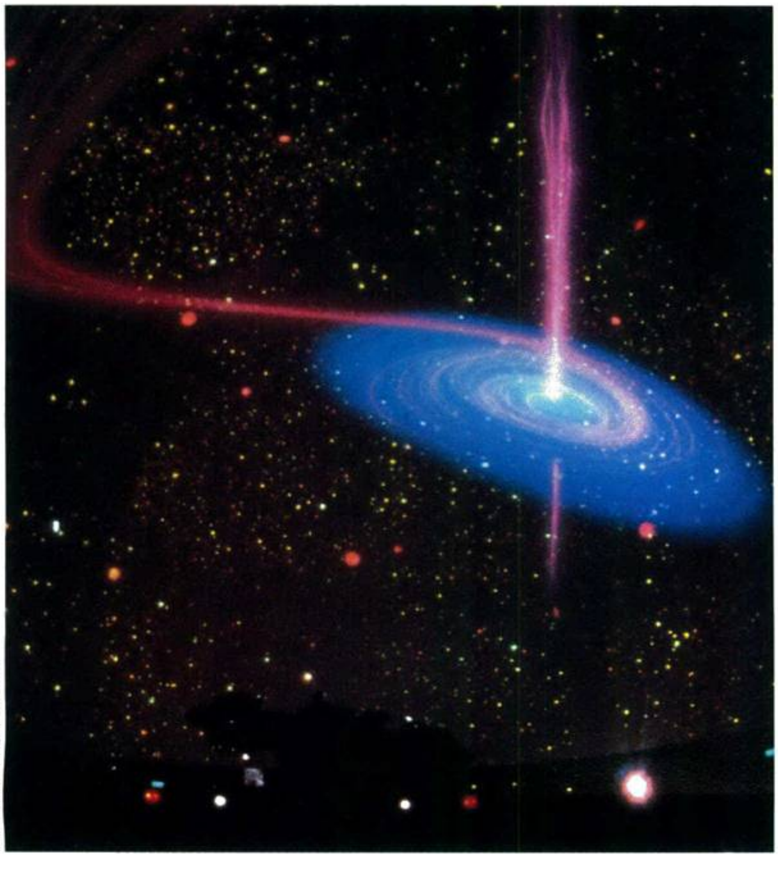
says James Manning, planetarium director at the Museum of the Rockies in Bozeman, Montana. "You're not stuck with sitting in your backyard with the same backyard sky all the time."

Digistar's sky is not as sharp as some would like, and it lacks color. But many planetaria appear to be voting for it with their checkbooks anyway. Since the 1994 debut of Digistar II — an updated system with sharper, brighter stars and smoother motions — Evans & Sutherland has outfitted nearly as many planetaria (24) as in all the years previous (28). And Digistar has snagged some pretty big fish. In Chicago, the Adler Planetarium and Astronomy Museum's new wing will boast a $2.75-million fully loaded Digistar planetarium.

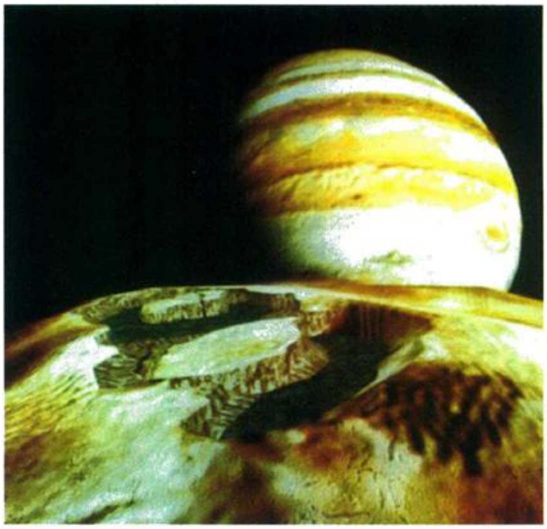
There are now 52 Digistar planetaria worldwide, with several more in the works, says Jeri Panek, education sales manager for Evans & Sutherland. She believes that Digistar II's improvements will enable it to gain even more ground on conventional star machines in years to come. "I'm not disputing that an optical sky is better than Digistar's, because the stars are sharper and smaller," Panek says. "But our new one has improved so much that many people say this is a really nice star field."

But it's not good enough for Mike Reynolds, executive director of the $52-million Chabot Observatory and Science Center now under expansion in Oakland, California. Reynolds found his dream machine at the Carl Zeiss Company of Jena, Germany. Chabot will be the first planetarium in North America to have the new Zeiss Universarium Mark-VIII.

Spiralling matter is drawn off a companion star toward a black hole in this Omniscan™ creation.



Audio Visual Imagineering, Inc.



Evans & Sutherland

Color, real-time, seamless computer imagery on a full-domed environment is StarRider's™ mission. Here the audience sees Jupiter setting on the horizon of Io.

Introduced last year, the M-VIII's 9,100 stars are projected from glass fibers, which makes for extremely bright, pointlike stars. It cost about $3 million, but to Reynolds the realistic Zeiss sky is worth it. "The reason we went with a Zeiss is we felt that — for the first time in planetarium history — it looked like the real night sky," he says. "In my experience, the thing that captivates and hooks people, is that beautiful night sky."

Still, Reynolds knows he must also make the stars dance. Chabot is considering a few options. One is to follow the example set in 1994 by the Astronaut Memorial Planetarium in Cocoa, Florida, which was the first in the world to install both a conventional projector and a Digistar under the same dome. Chabot is also considering a new kind of laser projection system called Omniscan. Made by Audio Visual Imagineering in Orlando, Florida, Omniscan uses rapidly moving laser beams to paint images on the dome in full color, including animated, anatomically correct constellation figures. Cost: $215,000.

The Virtual Planetarium

For now, institutions like Chabot and Astronaut Memorial that have the fund-raising muscle will have to rely on multiple projection systems to soup up their planetaria. But in Chicago, the Adler Planetarium is taking the first step toward the day when a single machine will allow people to bask under a vivid, colorful night sky and then fly into it — a true virtual reality theater where audiences can wander through a digital database of the universe at will. Call it the virtual planetarium.

As part of its $40-million addition, the Adler is installing StarRider, a new full-dome video projection system made by Evans & Sutherland. The system, consisting of six video projectors wired to a high-speed graphics computer, immerses visitors in a seamless hemisphere of color animation. A StarRider demonstration developed last year at

Pittsburgh's Buhl Planetarium featured a trip to Jupiter with the Galileo space probe. At Io, the fun really started. "We left Galileo and went down into a volcano on Io, flew around the caldera and back out," says Martin Ratcliffe, director of the Buhl Planetarium at the Carnegie Science Center in Pittsburgh. "As we backed away, out of Jupiter came this black monolith with a StarRider logo."

Tokyo's Goto Optical Manufacturing Corp. is also producing a full-dome video system, Virtuarium, with the same basic design as StarRider — six computer-driven projectors. (Goto's system runs off a Silicon Graphic Onyx, the same type of computer used to animate dinosaurs in *Jurassic Park.*)

A third manufacturer of conventional star machines, Spitz, Inc. of Chadds Ford, Pennsylvania, is offering a partial-dome system called Electric Sky that uses three projectors to wrap an image 200 degrees around the dome. According to Ed Lantz, product development manager for Spitz, the company expects to offer a full-dome system within the next three years.

In part, the introduction of full-dome video was driven by the special-effects arms race that produced *Jurassic Park* and other technical triumphs. "Our visual sophistication has gone up so high with all the movies coming out, from *Star Wars* to *Toy Story,* that the audience's expectations are extremely high," Ratcliffe says. "A star field will certainly keep the interest up for a while for those who are interested in astronomy, but for the general audience, you need additional things to hold that interest."

But there's more to immersive video than big-budget "infotainment," notes Neil deGrasse Tyson, director of the Hayden Planetarium at the American Museum of Natural History in New York City and an astronomer at Princeton University. Immersive video will enable planetaria to embrace the entire cosmos, as does astronomy itself. "What the new technologies enable us to do is take you off Earth's surface and move around the universe," Tyson says.

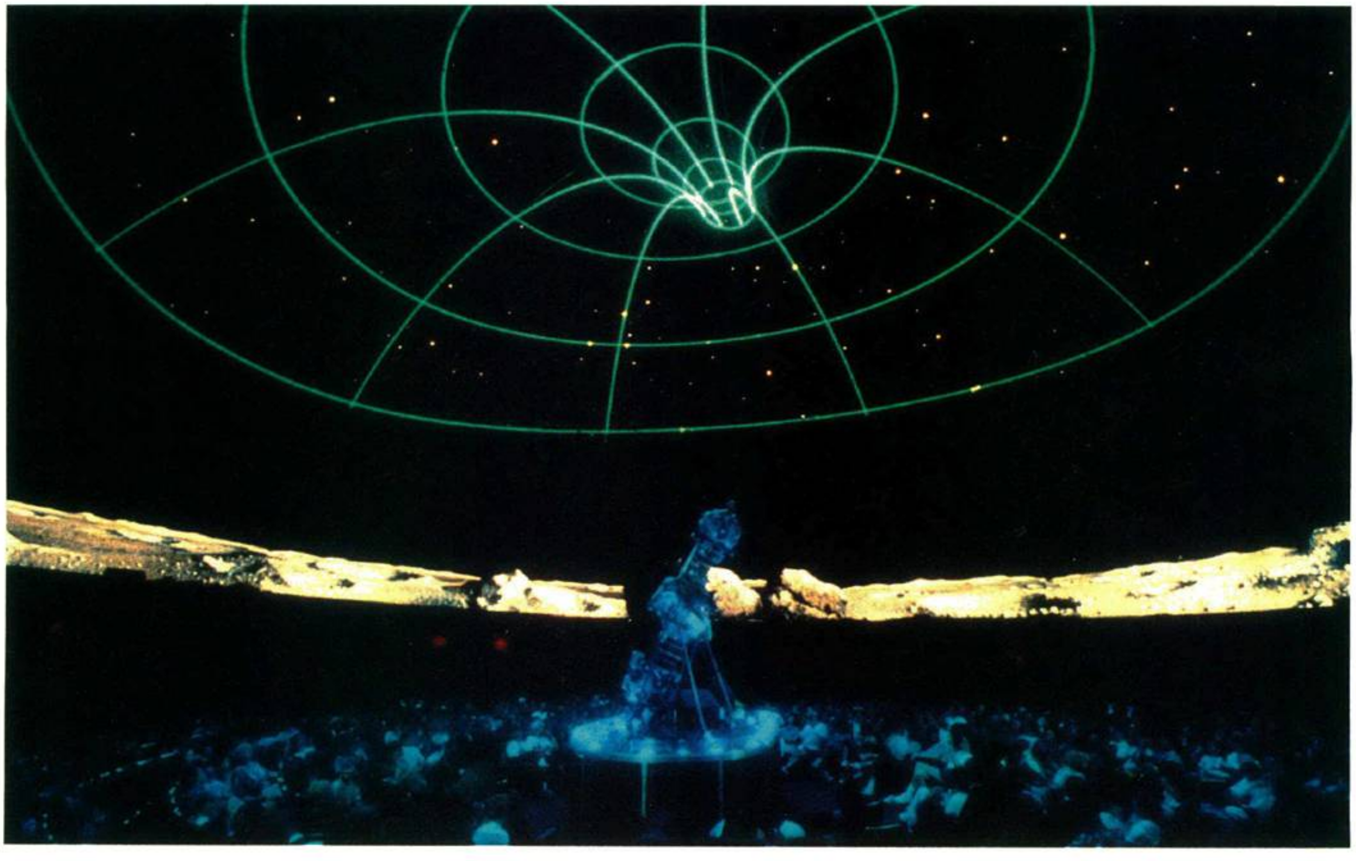
In a $135-million megaproject, the Hayden Planetarium is now being transformed into the Center for Earth and Space. Tyson says the center's new sky theater will have an immersive video system. The first thing he wants to do with it is take the public on tours through a database of all the latest information on the structure of the Milky Way. "This is one way we can take the fruits of research and use them to provide a meaningful experience for the visitor," Tyson says.

With rapid growth in graphics computing power and improvements in video projectors, the writing is on the dome for the conventional star machine, Spitz's Ed Lantz predicts. "My best guess is ten to twelve years. We're going to see systems that compete so thoroughly with star balls that you may not even want to buy a high-end opto-mechanical projector."

Banish the Stars?

But the transformation of the planetarium from a one-trick sky simulator to the virtual reality theater Lantz envisions could change the very

The Omniscan™ full-dome, color laser projection system simulates a black hole for the audience.



Audio Visual Imagineering, Inc.

Trailblazing Space Places

The Adler Planetarium: First in the Nation

In 1930, the first planetarium in North America opened in Chicago as the Adler Planetarium and Astronomical Museum. In 1998, Adler will have another first — a video projection system that covers the entire surface of its domed ceiling with color computer graphics. *Website: http://astro.uchicago.edu/Adler*

The Astronaut Memorial: Best of Both Worlds

When staff members at Brevard Community College in Cocoa, Florida, decided to renovate their planetarium, they had to choose which star machine to buy. The new planaterium houses both a multi-million-dollar Minolta Alpha Infinium projector for top-quality night sky *and* a Digistar for graphics — the best of both worlds in planetarium technology. *Website: http://www.brevard.ccflus/~planet*

The Hayden: Bringing the Universe to New York

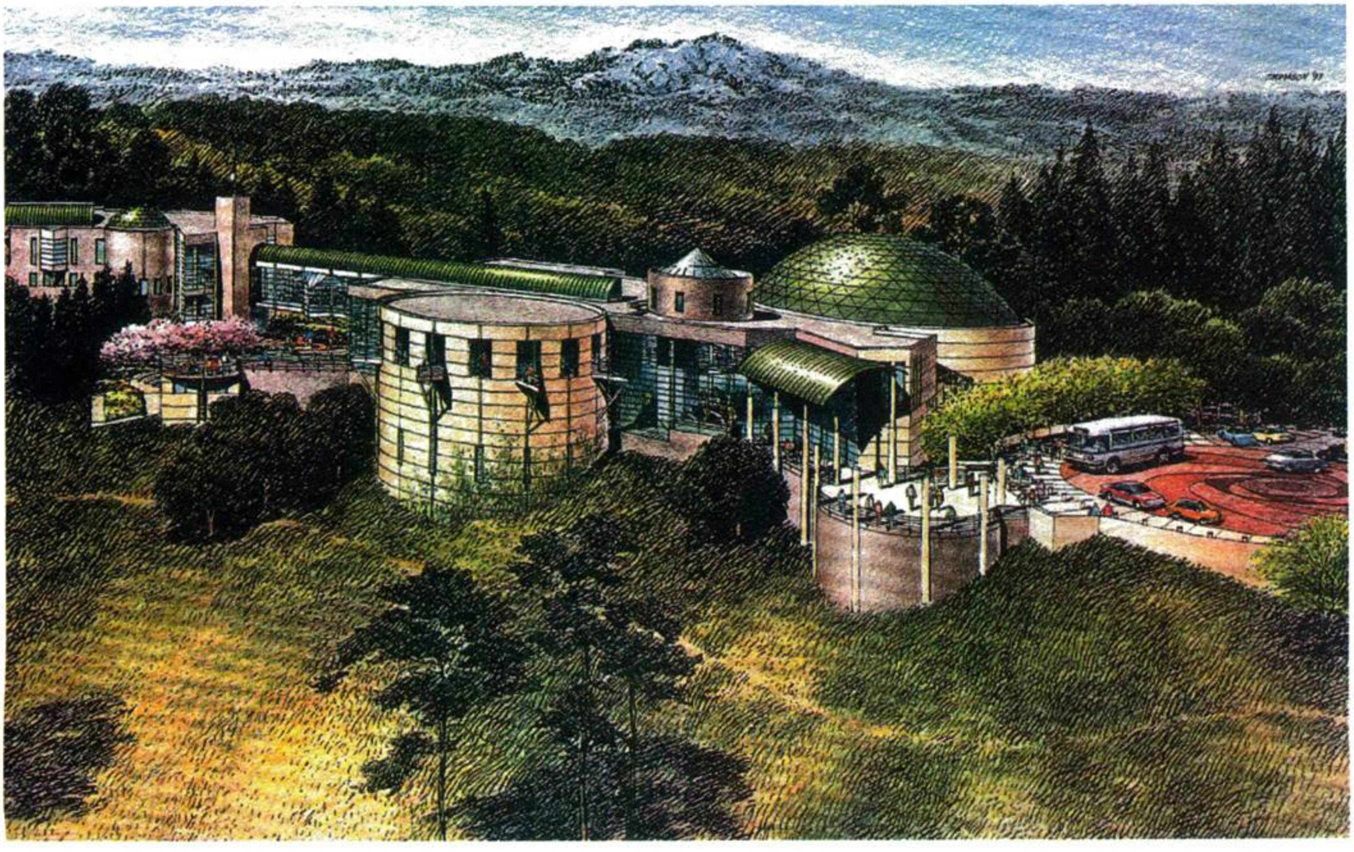
"It's our philosophical obligation to give New Yorkers the best sky there is because they don't get any," says Neil deGrasse Tyson, director. But there is more to the universe than the night sky, he adds, and the new science center was conceived to hold it all. The price tag: $135 million. *Website: http:www.amnh.org*

The Chabot: Proud History, Bright Future

When the Chabot Observatory was founded in Oakland, California, it made a fine home for Alvan Clark's first refractor. When it opens in 1999, the new Chabot Observatory and Science Center will include science exhibit halls, a 70mm film theater, four observatory domes, a small teaching planetarium and a larger, fully equipped planetarium for public programs. *Website:http://www.cosc.org*

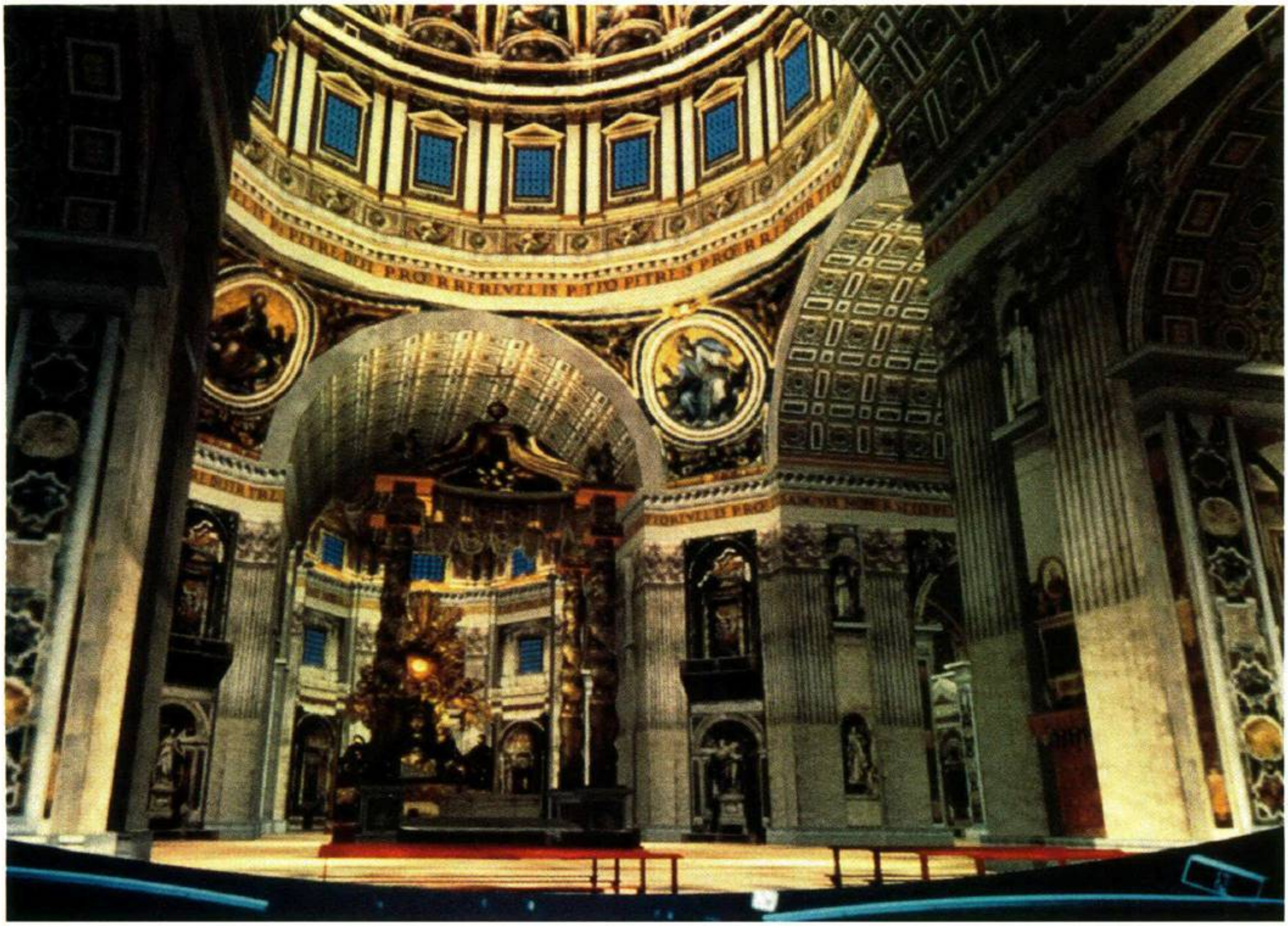
nature of the institution. In fact, something of an identity crisis is underway.

At science centers and museums, administrators are shunning the traditional label "planetarium" for more gelatinous monikers such as "futures theater" and "cyberdome." Perhaps this is a way of avoiding the stereotype of planetaria as places where bearded astronomers lecture about the constellations, Ratcliffe says. The trend could accelerate as immersive video makes it as easy to explore DNA as it is to explore the cosmos, throwing open the doors of the planetarium to all the sciences.



Chabot Observatory and Science Center

Founded in 1883, the Chabot Observatory is building a new home in a $52-million project.



ENEL SpA and Infobyte SpA

Goto Optical demonstrates its Virtuarium projection system with an image of St. Peter's Cathedral on a planetarium dome. Being here is like being in Vatican City.

Digistar has already begun the process: In "Journey into the Living Cell," the Buhl Planetarium used its Digistar system and video projectors to take audiences on a tour of biology rather than black holes.

Ratcliffe, who helped produce the show, welcomes the prospect of expanding the repertoire of the planetarium, although he wishes to remain solidly based in the stars. "We opened the door to a new audience that had never been here before," Ratcliffe says. "Those kids may bring their parents back for an astronomy show."

Others are wary of diluting the identity of the planetarium. "When they start teaching biology in there, can you even call it a planetarium?" asks George Reed, a former professor of astronomy at Westchester University in New York who does sales and training for Spitz star machines out of his Nevada home.

Reed wonders if the increasing use of video will accelerate what he believes is a decline in emphasis on teaching the visible sky in planetaria. He isn't opposed to the new video technology; he just hopes kids won't be too busy exploring bacteria and Buckyballs to learn about the sun, the moon, the stars, and other galaxies.

"There are a lot of things you can do with video that make for a dramatic production," he says. "But it's still getting away from the night sky."

That's okay with James Manning at the Museum of the Rockies. Every planetarium cannot be everything to all people, he says. Perhaps school districts and community colleges, which don't have the money for exotic video technology anyway, will become the centers of excellence in teaching while science centers and museums will push the technological limits.

"There's room for planetaria that can fill different niches and can concentrate on different strengths," Manning says, "whether it be the basics and good, sound educational practice or employing the new technologies to take people on whirlwind virtual reality tours."

Besides, in the planetaria of the future the message will still be as important as the medium — perhaps more important. "It's not really the technology, it's the shows that you produce at the end of the day," says Ian Griffin, director of the Astronaut Memorial Planetarium. "Everybody remembers his or her first trip to the planetarium. If we use the technology well, everyone should remember their first trip in generations to come, too." ■

Daniel Pendick lives in Milwaukee, Wisconsin, and is a contributing editor to Earth *magazine. From 1987-1990, he worked as a public lecturer and technician at the Link Planetarium in Binghamton, New York.*

Cooking up a Cosmos

Will our descendants create a universe in a laboratory?

by Alan Guth

YOU DON'T HAVE TO BE A MASTER CHEF TO MAKE meringue. Simply combine egg whites and sugar in a large bowl and beat vigorously until the mixture is light and fluffy. Spread in a pan and put in an oven preheated to 300 degrees F. Bake for 40 to 45 minutes and voilà! Could it be just as easy to make a universe?

Since the big bang theory implies that the entire observed universe can evolve from a tiny speck, it's tempting to ask whether a universe can in principle be created in a laboratory. Given what we know of the laws of physics, would it be possible for an extraordinarily advanced civilization to create new universes at will?

The first thing to think about is the list of necessary ingredients. Curiously, scientific theories continue to offer an enormous range of answers to the question of what the universe was made from. One of the most dramatic differences between the standard big bang theory (without inflation) and the inflationary universe theory is the answer that each gives to this fundamental question.

If the recipe for the standard big bang universe were written in a *Cosmic Cookbook*, how would it read? To begin the universe at an age of one second, the ingredient list would include 10^{89} photons, 10^{89} electrons, 10^{89} positrons, 10^{89} neutrinos, 10^{89} antineutrinos, 10^{79} protons, and 10^{79} neutrons. The ingredients should be stirred vigorously to produce a uniform batter, which should then be heated to a temperature of 10^{10} kelvins. After heating, the total mass/energy of the mix would be about 10^{65} grams, or 10^{32} solar masses. This number, by the way, is about 10 billion times larger than the total mass in the visible universe today. So, to produce a universe by the standard big-bang description, one must start with the energy of 10 billion universes! Since a chef's first task is to assemble the ingredients, this recipe looks formidable enough to discourage anybody.

The *Cosmic Cookbook* entry for an inflationary universe, on the other hand, looks as simple as meringue. In this case, the natural starting time would be the onset of inflation — just a fraction of a second after the Big Bang. In contrast to the standard big bang recipe, the inflationary version calls for only a single ingredient: a region of false vacuum (see "The False Vacuum," page 56). And the region need not be very large. A patch of false vacuum 10^{-26} centimeter across might be all the recipe demands. While the mass required for the previous recipe was 10^{32} solar masses, the mass in this case is only an ounce: about the mass of a slice of bread. So, in the inflationary theory the universe evolves from essentially nothing at all, which is why I frequently refer to it as the ultimate free lunch.

Does this mean that the laws of physics truly enable us to create a new universe at will? If we tried to carry out this recipe, unfortunately, we would immediately encounter an annoying snag: Because a sphere of false vacuum 10^{-26} centimeter across has a mass of one ounce, its density is a phenomenal 10^{80} grams per cubic centimeter. For comparison, the density of water is 1 gram per cubic centimeter, and even the density of an atomic nucleus is only 10^{15} grams per cubic centimeter. If the mass of the entire observed universe were compressed to false-vacuum density, it would fit in a volume smaller than an atom.

The mass density of a false vacuum is not only beyond the range of present technology, it is beyond the range of any

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Philip Anderson

THE FALSE VACUUM

The false vacuum is a peculiar form of matter predicted to exist by modern theories of elementary particles. If inflationary cosmology is correct, it was the driving force behind the Big Bang. The false vacuum has an extraordinarily high density, perhaps 10^{80} grams per cubic centimeter, and also a pressure that is extraordinarily large, but negative — it acts like a suction. The huge negative pressure turns gravity on its head, producing a repulsive gravitational force that can launch a region of false vacuum into explosive expansion.

Why does the false vacuum have such a peculiar name? While the word "vacuum" is often defined as a state devoid of matter, this definition is not precise enough for physicists, since it is not clear exactly what "matter" means. The physicist defines "vacuum" as the state with the lowest possible density of energy. The false vacuum is not really a vacuum, but its energy density can be lowered only by a very slow process, called the decay of the false vacuum. So, while the false vacuum is waiting to decay, it behaves as if its energy density cannot be lowered — as if it were a temporary vacuum.

conceivable technology. As a practical matter, therefore, I would not recommend buying stock in a company that intends to market do-it-yourself universe kits. Nevertheless, I will dismiss the gargantuan mass density of the false vacuum as a mere engineering problem, boldly assuming that some civilization in the distant, unforeseeable future will be capable of creating such densities. Is it possible, given what we know of the laws of physics, that someday our descendants might produce new universes by slicing pieces of false vacuum? On the darker side, does the physics of the false vacuum create the possibility of an ultimate doomsday machine? Is our universe imperiled by the threat that a super-advanced civilization in some remote galaxy might create a cancerous patch of false vacuum that would engulf us all?

The first step in trying to fabricate a laboratory universe is to create a patch of false vacuum. How exactly this can be achieved depends on the details of physics at extremely high levels of energy (more than a trillion times higher than modern particle accelerators), which at present we have no way of knowing. This part of the problem, therefore, will be left for our descendants to solve. At present, we can say that our current theories offer several possibilities. In many theories, the desired false vacuum can be created by heating a region of space to enormous temperatures (perhaps 10^{29} kelvins), and then rapidly cooling it. The region would then supercool into the false vacuum, exactly as we imagine that the early universe may have done.

Once a patch of false vacuum is created, its evolution does not depend on how it was created. The false vacuum is characterized by having a huge energy density and a huge but negative pressure. Through the equations of general relativity, these properties alone determine how space-time is distorted by a region of false vacuum.

Because the false vacuum creates a strong gravitational repulsion, we expect that the region of false vacuum will grow. However, if the false vacuum bubble wall is to move outward, there must be a force pushing it that way. The pressure outside the bubble is zero, and the pressure inside is negative. The pressure is therefore higher outside than inside, so the pressure difference will push inward on the bubble wall.

One might guess that the gravitational repulsion of the false vacuum would push outward on the bubble wall, so if this repulsion were strong enough, the bubble would start to grow. Not so, however, say the equations of general relativity. The gravitational repulsion causes the false vacuum to swell, but the repulsion does not extend beyond the false vacuum. Objects outside the bubble wall are attracted *toward* the bubble, and the gravitational force on the bubble wall is *inward*.

Because both pressure and gravity pull inward on the bubble wall, a bubble that is started from rest will start to contract. With nothing to halt the contraction, it will collapse to a black hole. While a black hole is interesting, it would certainly be viewed as a disappointment by our would-be universe creator.

Suppose, however, that the bubble was not started from rest, but instead was given an outward push. If the initial outward velocity is large enough, then the bubble will follow the sequence shown in the figure on the facing page. As the bubble grows, the indentation will become deeper, as shown at the top. The indentation will continue to deepen, developing a neck, or wormhole, as shown in the middle. Once the wormhole develops, a dramatic change takes place — the bubble has turned inside out. Now the region of false vacuum can grow larger and larger without encroaching on the original space. It creates new space as it expands, resembling an inflating balloon. The climax of the evolution is shown at the bottom: The region of false vacuum, with a region of true vacuum attached, disconnects from the parent space, forming a new, completely isolated closed universe. It will then continue to enlarge, going through the usual evolution of an inflationary universe. A new universe has been created, and the parent universe is unharmed — universe creation is not a doomsday machine. From the point of view of the parent universe, the "umbilical cord" of the child universe is indistinguishable from a black hole. The umbilical connection in the child universe would similarly look like a black hole.

If we assume that the false vacuum driving the inflation has a mass density of about 10^{80} grams per cubic centimeter, then the time that it takes the child universe to disconnect is roughly 10^{-37} second. After this time there will be no contact between the parent universe and child. A false-vacuum-bubble universe creator would watch helplessly as his new universe slipped inexorably through the wormhole and severed all contact. Once the new universe has separated, the black hole that remains in the parent universe would evaporate. It would disappear in roughly 10^{-23} second, releasing the energy equivalent of a 500-kiloton nuclear explosion. While the parent universe would be in no danger of annihilation, the safety of the experimenters would require precautions similar to those used in hydrogen bomb tests.

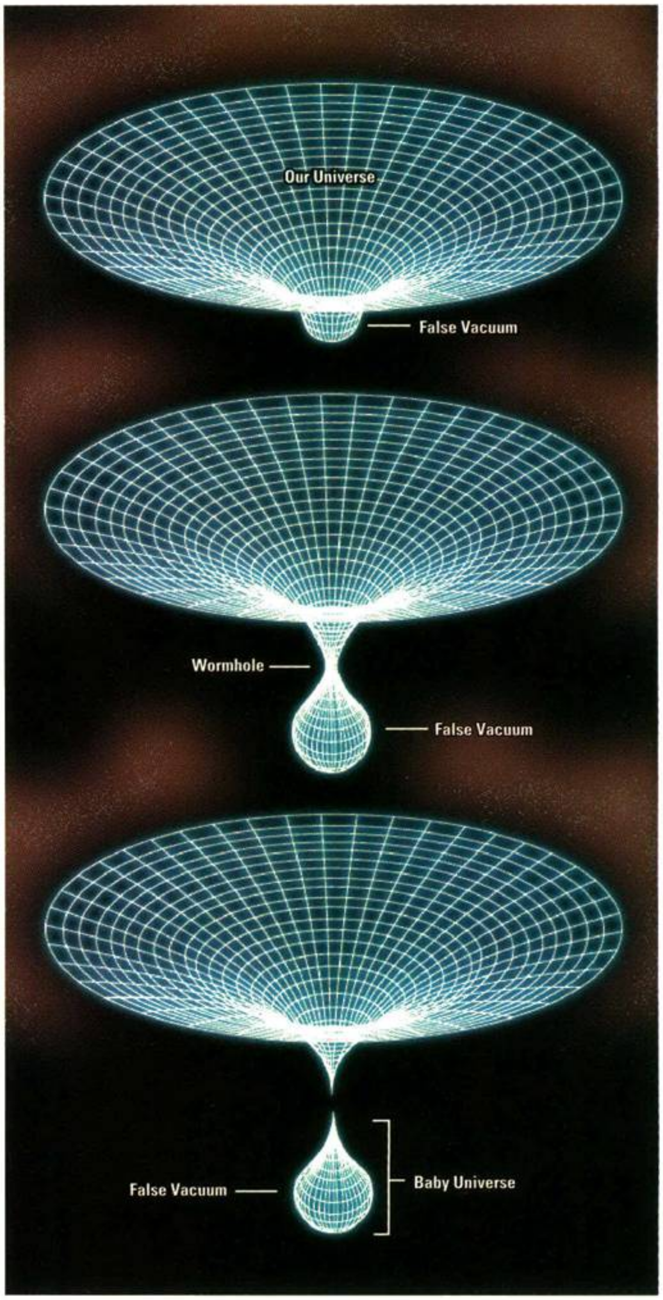
The story of inflationary universe creation sounds complete at this point, but there is an important and surprising twist: It is not clear whether it is possible, even in principle, to attain the expansion velocity needed for the false vacuum bubble to evolve into a new universe.

One hope for evading this problem involves a peculiar consequence of quantum theory, the process of quantum tunneling. A quantum system can make a discontinuous transition from one configuration to another, even when the system would not normally have enough energy to exist in the intermediate configurations. This "quantum leap" is the origin of a frequently used metaphor (and a successful American television series), and it also plays a crucial role in the decay of the false vacuum.

But calculations show that each time a false vacuum bubble is set into expansion, the probability that it will tunnel to become a new universe is extraordinarily small. To write out the number in decimal notation would require a decimal point, followed by approximately 10^{13} zeros, followed by a one. So even if some super-advanced civilization develops the capacity to produce and manipulate regions of false vacuum, they would still require a fantastic amount of patience to produce a new universe.

It may be premature, however, for us to bemoan the difficulties that our super-advanced descendants will face. Calculations show that the probability becomes higher as the mass density of the false vacuum increases. If there exists a false-vacuum state associated with the unification of gravity and the other three forces of nature, then the mass density would be about 10^{93} grams per cubic centimeter. For this density, the answer to our probability calculation would be approximately one — a new universe would be created with just about every attempt.

While advanced civilizations can conceivably create multiple universes, inflation itself can have the same effect. Most versions of the inflationary universe theory imply that the false vacuum does not decay all at once, but instead decays a fragment at a time. Each fragment produces a universe, while the bulk of the false vacuum continues eternally to double and redouble in size. Each doubling in size might occur in as little as 10^{-37} second. Because the time needed for the development of a super-advanced civilization is measured in billions of years or more, there appears to be no chance that laboratory production of universes could compete with the "natural" process of eternal inflation.



Astronomy: Terri Metzger

If a civilization can cause a false vacuum bubble to expand fast enough, it can create a new universe. The false vacuum bubble, shown as a two-dimensional slice, begins to inflate (top). In the second phase, the false vacuum bubble continues to expand like a balloon and a thin neck called a wormhole develops. In a tiny fraction of a second, shown at the bottom, a baby universe detaches from the parent universe and is free to inflate. The parent universe remains unharmed.

On the other hand, a child universe created in a laboratory by a super-advanced civilization would set into motion its own progression of eternal inflation. Could the super-advanced civilization find a way to enhance its efficiency? We may have to wait a few billion years to find out.

Alan Guth (ahg-inflate@ctp.mit.edu) is a physicist at the Massachusetts Institute of Technology in Cambridge. He originated the inflationary universe theory in 1979.

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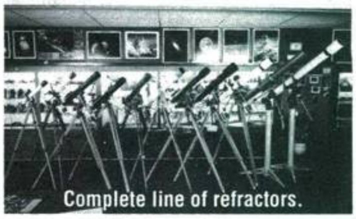
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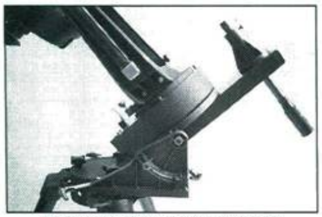
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For astronomy you can enjoy breathtaking views of the Moon, Saturn with its ring structure, Jupiter and its belts and hundreds of deep-sky objects including galaxies, nebulae and star clusters. With a solar filter (optional) you can observe activity on the Sun. For terrestrial use, enjoy vistas from view homes or take your instrument out in the field to take advantage of our natural environment up close.

Standard accessories include a 6x30 Finderscope, 1¼" Focuser, 25mm SMA Eyepiece – 1¼" (36x), Star Diagonal – 1¼". Weight is 24 lbs.

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Celestron offers two models of 102mm (4") equatorial refractor telescopes. These telescopes are for the more serious astronomer who appreciates superb optics and ultra-stable mounts.

The Great Polaris (GP) German equatorial mount is standard. Both axes have precision 144-tooth lapped worm gears for very smooth motion. The adjustable height, very rigid wood tripod has excellent vibration dampening characteristics and has a handy accessory tray.

The GP mount has a built-in illuminated polar alignment scope for fast polar alignment.

The premium optics of the **GP-C102** are made in Japan to rigid standards. It has a focal length of 1000mm (f/9.8). The **GP-C102-ED** model features Super ED glass to yield exquisite images of very high contrast and resolution with virtually no chromatic aberration. The ED unit has a focal length of 920mm (f/9) and has multi-coatings.

Standard accessories (the same on both models), include a 20mm Eyepiece – 1¼", 6x30 Finderscope with an 8° field and a Star Diagonal – 1¼". Weight is 39 lbs.

Optical tube assemblies of the 4" refractors are available separately and include tube rings, mounting plate and finderscope.

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FIRSTSCOPE 60

A 700mm focal length (f/11.7) telescope which contains all glass optical components with coated optics.

The glossy black telescope optical tube is made of aluminum. The sturdy altazimuth mount has a slow-motion control rod for vertical adjustments. The rigid, adjustable wood tripod includes an accessory tray.

Standard accessories include a 20mm H – .96" Eyepiece (35x), 6mm SR – .96" Eyepiece (117x), 2x Barlow Lens – .96", 5x24 Finderscope and a 90° Diagonal.

FIRSTSCOPE 60 DELUXE

The same as the Firstscope 60 except that all the .96" items are replaced with a **hybrid 1¼" diagonal and two 1¼" eyepieces** – 25 SMA (28x) and 10mm SMA (70x).

Celestron offers two 60mm equatorial refractors – the Firstscope 60 EQ and the Firstscope 60 EQ Deluxe.

FIRSTSCOPE 60 EQ

Similar to the Firstscope 60 but the focal length for this telescope is 900mm (f/15).

Standard accessories include a 20mm H – .96" Eyepiece (45x), 12.5mm H – .96" Eyepiece (72x), 2x Barlow Lens – .96", 6x24 Finderscope and a 90° Diagonal. Weight is 11 lbs.

FIRSTSCOPE 60 EQ DELUXE

The same as the Firstscope 60 EQ except that all the .96" items are replaced with a **hybrid 1¼" diagonal and two 1¼" eyepieces** – 25mm SMA (36x) and 10mm SMA (90x).

The 1¼" accessories give you sharper images, a wider field of view and better eye relief. Weight is 11 lbs.

Celestron offers a premium grade 80mm (3.1") altazimuth refractor – **The Premium 80.** The premium built optics are made in Japan.

The Premium 80 is an ideal first telescope for the more serious beginning astronomer or terrestrial observer.

Its easy-to-use altazimuth mount includes slow-motion controls in both axes with flex cables allowing quick and easy pointing and tracking. The supplied attractive and very sturdy wood tripod is adjustable in height.

Standard accessories include a 26mm multi-coated Plössl – 1¼" Eyepiece (35x) for a wide field of 1.4°, high quality 6x30 Finderscope and a versatile 45° Erect Image Diagonal – 1¼". Weight is 18 lbs.

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THE SKY SHOW

Autumn's chill ushers in a season for planet-lovers. Jovian moons continue a game of hide and seek, while our moon covers up the Ringed Planet. by Martin Ratcliffe and Alister Ling

▶ The September sky rolls gently by, ushering in a season of gradual change to cooler temperatures. The equinox on September 22 marks the official beginning of autumn, although a slight nip in the air might make us think fall is arriving sooner rather than later.

In the growing chill, look for Venus shining brightly during evening twilight. It lingers around the western horizon for about 90 minutes after sunset. Through a telescope it presents a gibbous phase, a phase that is slowly but surely shrinking. By the end of the year it will be a crescent.

Venus's rapid southerly motion as compared to the stars keeps it relatively low in the sky until November. An hour after sunset, the planet stands less than 10° above the horizon. During late twilight Spica, the 1st-magnitude star in Virgo, punches through the sun's ebbing glow. On September 5 it lies 2° south of Venus. A slim crescent moon joins the pair just 3° north of Venus to provide a striking opportunity for photographers.

By early October, Venus catches up with 1st-magnitude Mars. Mars's own motion takes it to within a degree of Delta (δ) Scorpii, shining at magnitude 2.3, by the end of September. Low in the southwest during late September evenings, the Red Planet's fading aura finally yields in brightness to Scorpius's Antares, a star whose name means "Rival of Mars" in ancient Greek. There is, however, only a 0.1-magnitude difference between the two.

Larry Landolfi

Scorpius the Scorpion is a sprawling, hook-shaped constellation, one of the sky's rare star patterns that actually looks like its namesake. Its claws, represented by an arc of 2nd-magnitude stars in which Delta Scorpii lies, are sometimes depicted as holding the scales of neighboring Libra.

Scorpius is the alleged slayer of Orion the Hunter, who occupies a region opposite Scorpius in the sky. As the scorpion rises, so the hunter sets. Yet Scorpius itself is seemingly in danger from neighboring Sagittarius the Archer who wields a dart or arrow. The scorpion's stinger, a graceful curve of stars southeast of Antares and visible from the latitude of observers in North America, appears positioned to ward off any attack from Sagittarius.

Although one of the zodiacal constellations, Scorpius only hosts the sun nine days out of the year in two small regions that project upward into Ophiuchus.

Besides the occasional bright, star-like planet, a number of famous "new stars" have briefly appeared within Scorpius's borders: Chinese and Greek astronomers recorded a "strange star" in 134 B.C, the first recorded appearance of a nova or exploding star.

Antares, which shines at magnitude 1.0, is a red supergiant star and was known to the Romans as Cor Scorpionis, the "Heart of the Scorpion." Studies have measured the apparent disk of the star at about 0.041 arcseconds, which means Antares must be 700 times the diameter of our sun, or 600 million miles across.

However, its mass is only 15 times that of the sun, indicating an extremely low density for the outer regions of the star. Antares has a 6th-magnitude companion lying just 3" away. The brilliance of nearby Antares makes this double star a real challenge through a 6-inch telescope, and it is visible only during nights of exceptional atmospheric steadiness.

Scorpius is also home to a number of fine Messier objects, first cataloged as nuisances by the 18th-century comet-hunter Charles Messier. M4, a magnitude 7.4 globular cluster, is easily found just over 1¼° due west of Antares. To the southeast near the border with Sagittarius lie magnitude 4.2 M6 and magnitude 3.3 M7, a pair of loose open

Autumn's approach ushers in longer, cooler nights. Skies seem washed clean of summer's hazy humidity. The summer stars linger into early evening, only to surrender to winter constellations as the night wears on.

SEPTEMBER 1997

1 New moon is at 7:52 p.m. EDT; partial solar eclipse

2 The moon is at apogee (252,574 miles from Earth), 5:18 p.m. EDT

5 The moon passes 3° north of Venus, 8 a.m. EDT (page 67)

6 Venus passes 1.9° north of Spica, 1 a.m. EDT

7 The moon passes 5° north of Mars, 5 a.m. EDT

9 First quarter moon is at 9:31 p.m. EDT

12 The moon passes 4° north of Neptune, 9 p.m. EDT

13 The moon passes 4° north of Uranus, 10 a.m. EDT
Asteroid Harmonia is at opposition, 9 p.m. EDT
The moon passes 4° north of Jupiter, midnight EDT

16 The moon is at perigee (221,808 miles from Earth), 11:23 a.m. EDT
Full moon is at 2:50 p.m. EDT; total lunar eclipse
Mercury is at greatest western elongation (18°), 6 p.m. EDT (page 66)

18 The moon passes 0.2° north of Saturn, 6 a.m. EDT (page 69)

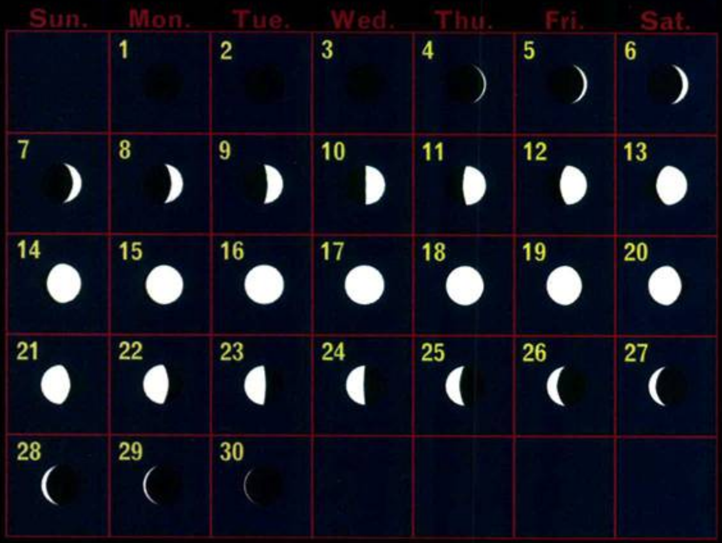
21 The moon passes 0.3° north of Aldebaran, 8 p.m. EDT

22 Autumnal equinox is at 7:56 p.m. EDT

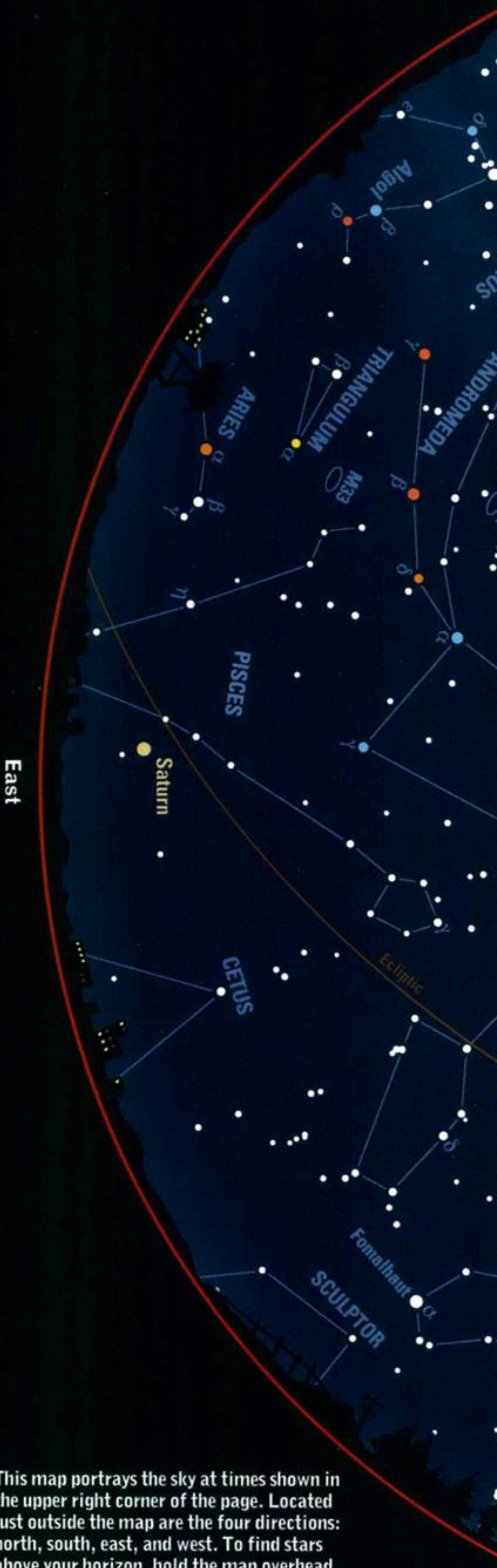
23 Last quarter moon is at 9:35 a.m. EDT

27 Asteroid Flora is at opposition, 2 a.m. EDT

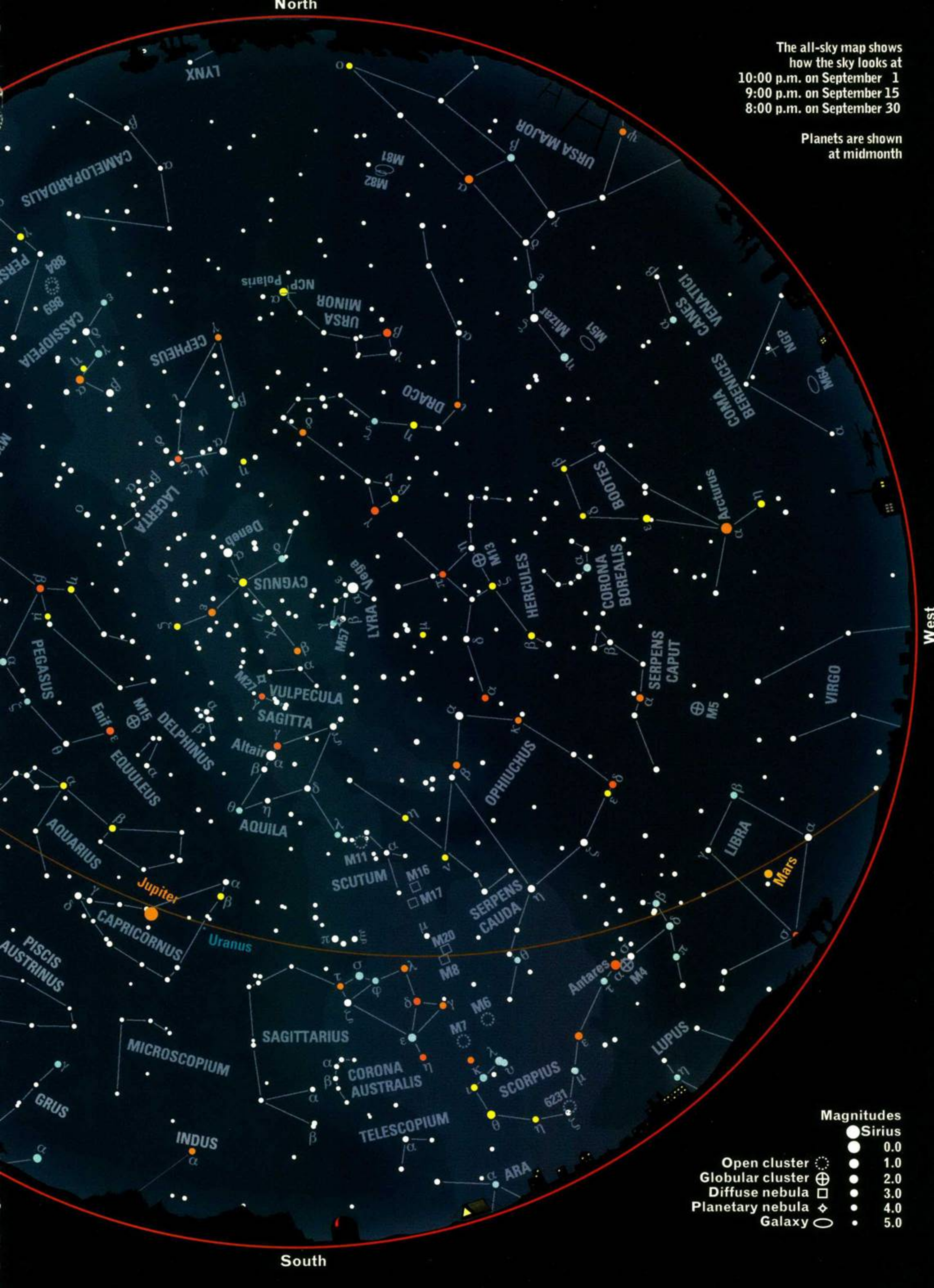
29 The moon is at apogee (252,482 miles from Earth), 7:30 p.m. EDT



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				



This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
LYNX
URSA MAJOR
CAMELOPARDALIS
M81
M82
PERS
884
869
CASSIOPEIA
NCP Polaris
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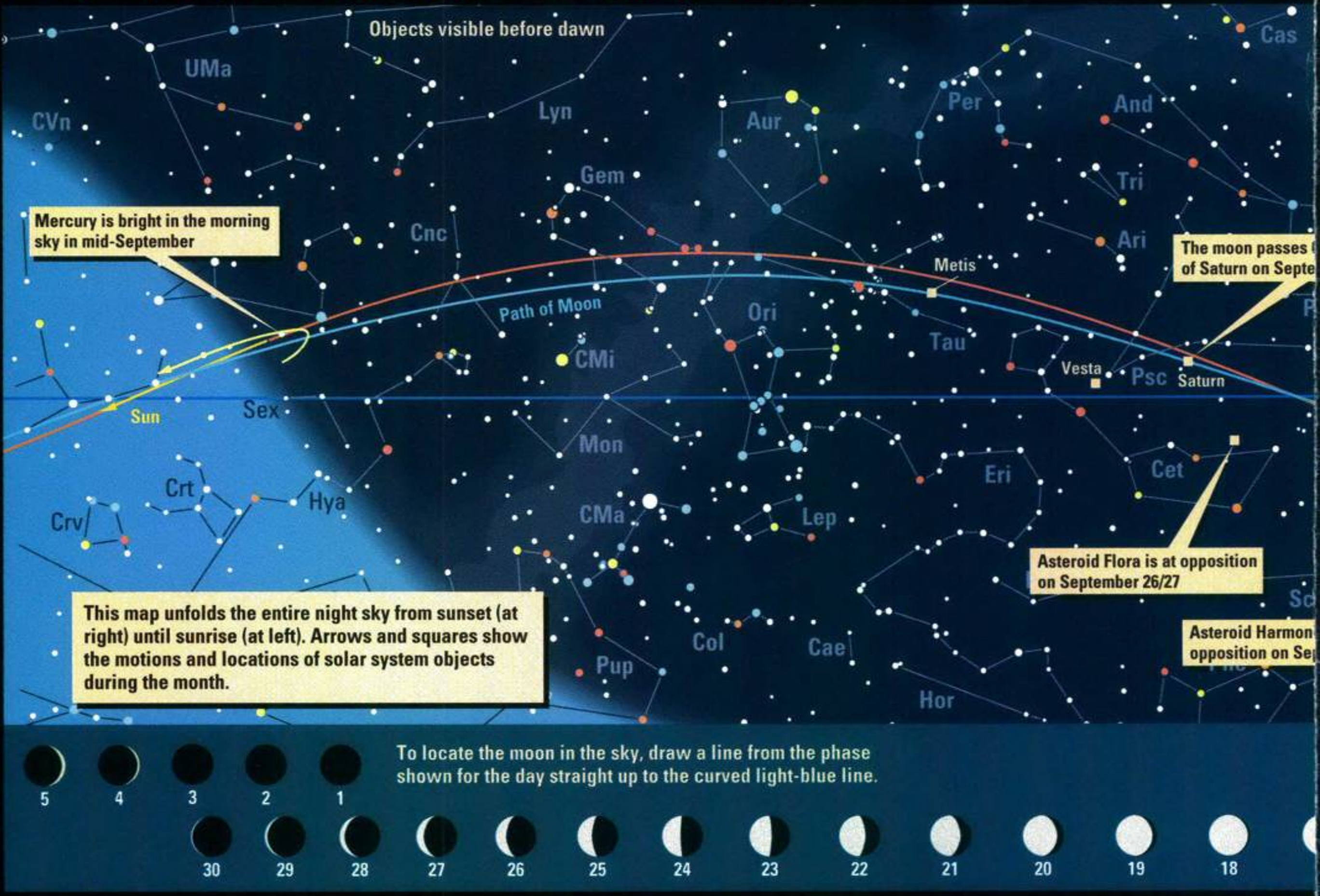
CEPHEUS
Mizar
M51
CANES VENATICI
NGP
COMA BERENICES
M64
DRACO
LACERTA
BOOTES
Arcturus
Deneb
CYGNUS
Vega
LYRA
M57
M13
HERCULES
CORONA BOREALIS
West
PEGASUS
M27
VULPECULA
SAGITTA
SERPENS CAPUT
M5
VIRGO
Enif
M15
DELPHINUS
Altair
EQUULEUS
OPHIUCHUS
AQUILA
AQUARIUS
M11
SCUTUM
M16
M17
LIBRA
Mars
Jupiter
CAPRICORNUS
Uranus
SERPENS CAUDA
PISCIS AUSTRINUS
M20
M8
Antares
M4
MICROSCOPIUM
SAGITTARIUS
M6
M7
LUPUS
CORONA AUSTRALIS
SCORPIUS
GRUS
6231
INDUS
TELESCOPIUM
ARA
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
10:00 p.m. on September 1
9:00 p.m. on September 15
8:00 p.m. on September 30

Planets are shown
at midmonth

THE PATH OF THE PLANETS


Objects visible before dawn
UMa
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Metis
Path of Moon
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Vesta
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Saturn
Sun
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Mercury is bright in the morning sky in mid-September

The moon passes
of Saturn on Septe

Asteroid Flora is at opposition on September 26/27

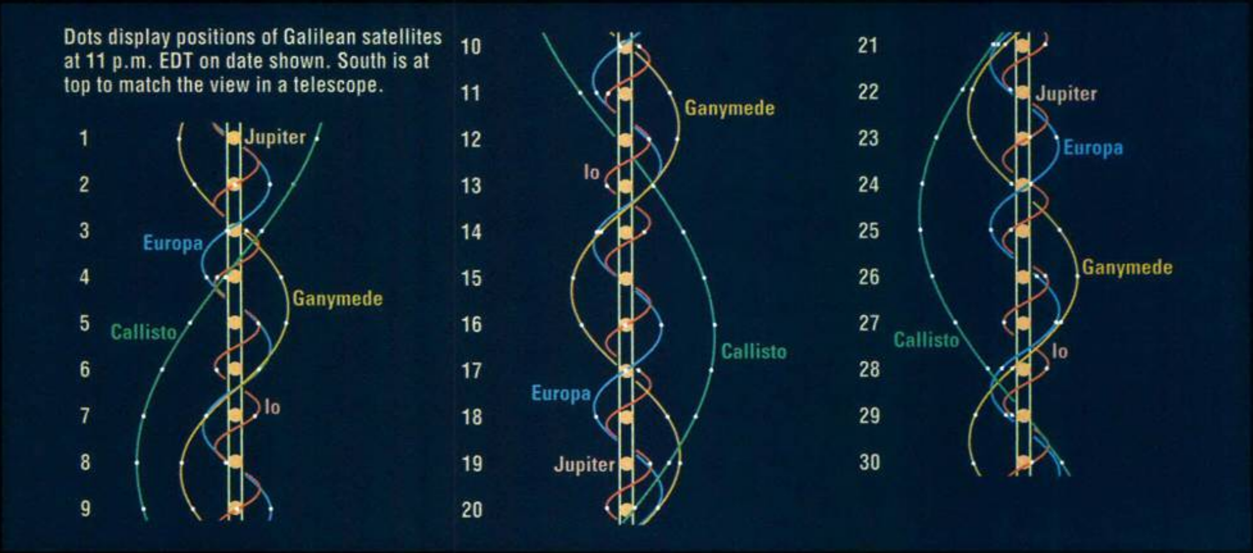
Asteroid Harmon
opposition on Se

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and squares show the motions and locations of solar system objects during the month.

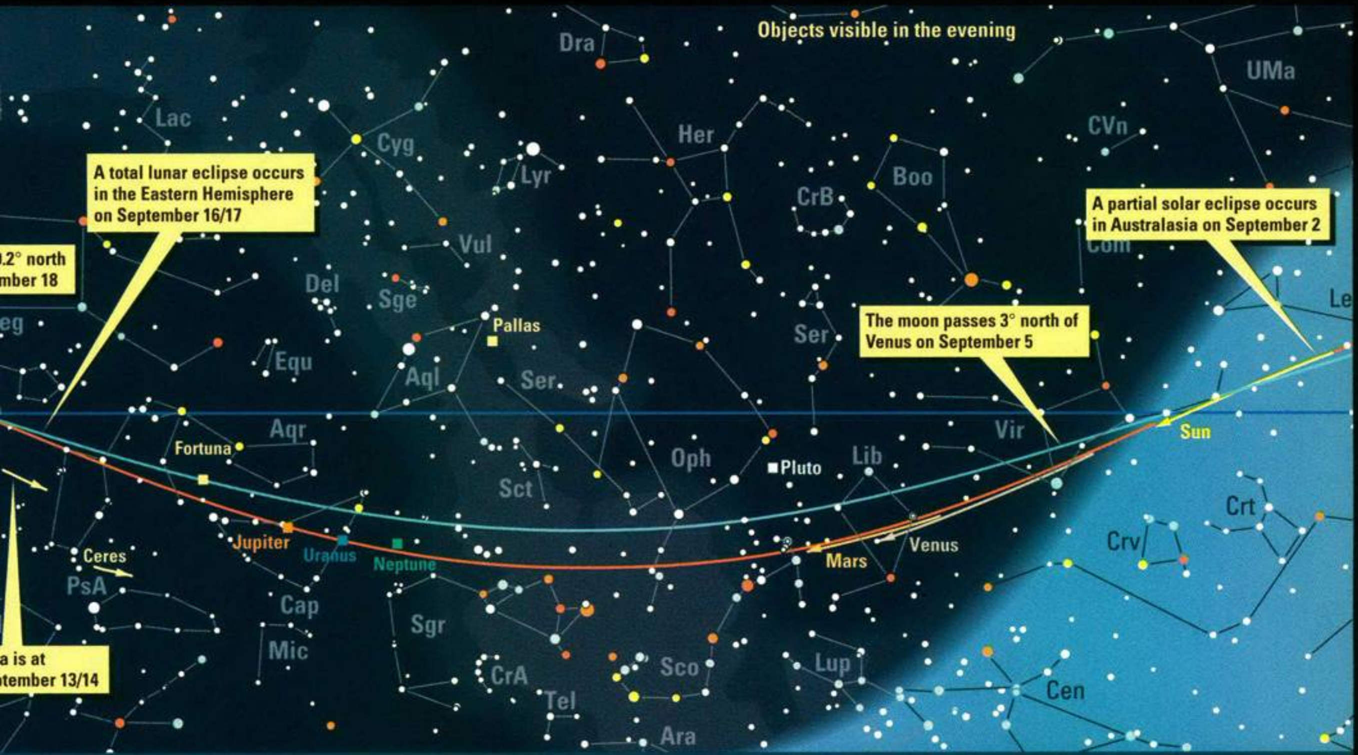
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPIT
Date	September 15	September 30	September 15	September 15	Septemb
Magnitude	0.0	–1.2	–4.1	1.1	–2.7
Angular Size	7.6"	5.3"	15.8"	5.5"	46.6"
Illumination	39%	91%	71%	91%	100%
Distance (AU) from Earth	0.890	1.265	1.058	1.717	4.233
Distance (AU) from Sun	0.313	0.341	0.727	1.463	5.052
Right Ascension (2000.0)	10h26.0m	11h48.4m	14h03.5m	15h11.1m	21h03.
Declination (2000.0)	9°59'	3°18'	–13°29'	–18°46'	–17°5

JUPITER'S MOONS


Dots display positions of Galilean satellites at 11 p.m. EDT on date shown. South is at top to match the view in a telescope.

Objects visible in the evening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Jupiter
Uranus
Neptune
Mars
Venus
Ceres
PsA
Cap
Sgr
Mic
CrA
Sco
Lup
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Ara

A total lunar eclipse occurs in the Eastern Hemisphere on September 16/17

A partial solar eclipse occurs in Australasia on September 2

The moon passes 3° north of Venus on September 5

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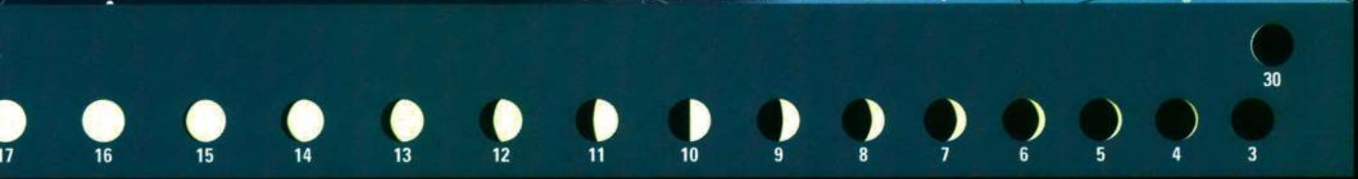
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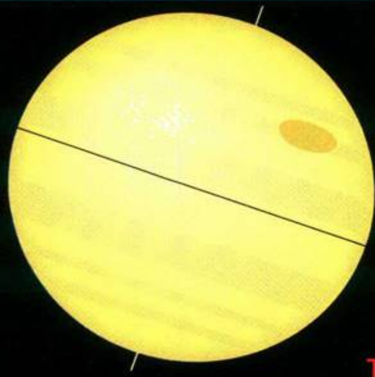
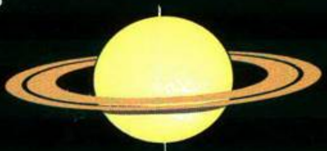
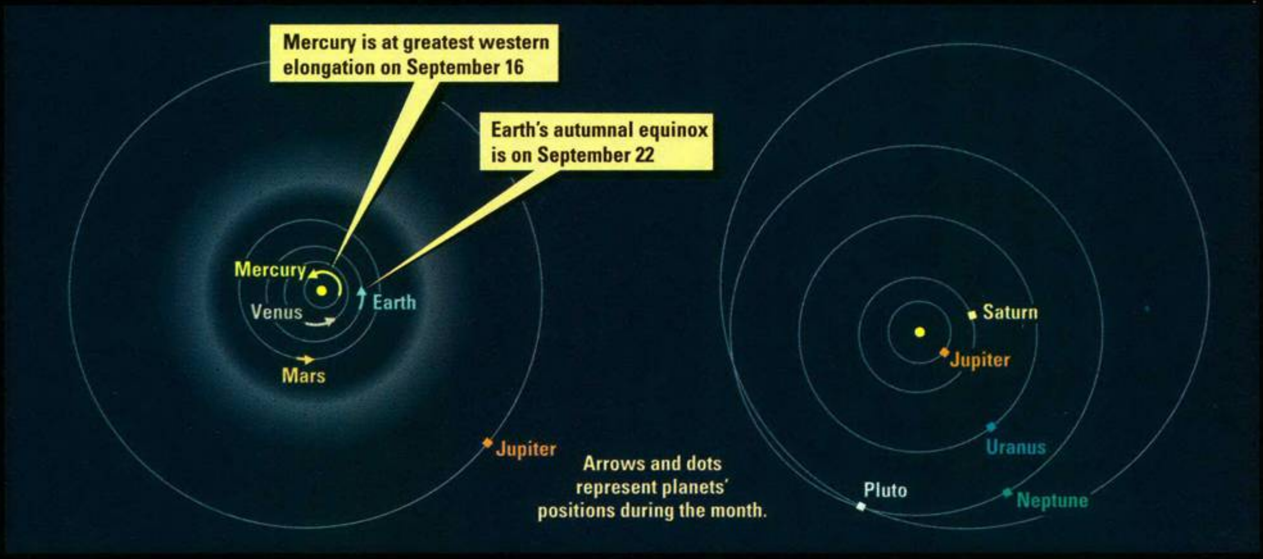




ER	SATURN	URANUS	NEPTUNE	PLUTO
er 15	September 15	September 15	September 15	September 15
	0.2	5.7	7.9	13.8
	19.6"	3.7"	2.3"	0.1"
	100%	100%	100%	100%
	8.488	19.133	29.559	30.310
	9.397	19.831	30.149	30.004
m	1h13.6m	20h30.5m	19h57.4m	16h13.9m
'	4°51'	–19°37'	–20°18'	–8°46'

THE PLANETS IN THEIR ORBITS


Mercury
Earth
Venus
Mars
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Mercury is at greatest western elongation on September 16

Earth's autumnal equinox is on September 22

Arrows and dots represent planets' positions during the month.

First Views: The Milky Way by Eye

What greater magnificence can there be than a starry night with the summer Milky Way arching high overhead? There, as plain as day, is our home spiral galaxy the Milky Way viewed edge-on. The beauty of this is that you don't need a big telescope to view an edge-on galaxy. Backyard observers routinely hunt down edge-ons like NGC 891 in Andromeda and NGC 4565 in Coma Berenices. Our home galaxy is 500 times closer, and requires no optical aid and just a little patience to enjoy.

With a little help, you can begin to understand the structure of our home galaxy. There's more to what you see than a sweeping arch of light. A veritable chasm of darkness runs from Cygnus into Sagittarius — the Great Rift. It is nothing more than a lane of dust and gas that keeps starlight from shining through from behind.

Veteran deep-sky observers have seen similar features in edge-on galaxies or on the north side of M31, the Andromeda Galaxy. Binoculars are the best tool for gawking at an amazing network of dark nebulae that accompanies the Great Rift. But it's the naked-eye view that conveys the real character of this portion of the Milky Way.

Cygnus Star Cloud

Hidenori Nohara

Scutum Star Cloud

Ronald Royer

Looking toward Sagittarius, we are facing the center of our galaxy. The Milky Way is widest here and richest in clusters and nebulae. We're also looking through a few intervening spiral arms. A view into one arm lies in Scutum, near the southwest corner of Aquila. Here stars literally pile up behind the foreground objects, until we're looking at a glowing patch of Milky Way called the Scutum Star Cloud. The apparent star density here is unbelievable. If Earth weren't blocking our view into the south, we'd turn our heads and stare right down the other side of this spiral arm to see the Norma Star Cloud. The Scutum portion of this spiral arm curves behind Aquila to lie hidden from our view by more dust. While in this area, be sure to check out the open star cluster M11.

Moving north up the Milky Way, jump from one spiral arm to another, across the Great Rift. Suddenly we're looking right down the arm that harbors the sun. All the stars in our neighborhood curve away to form a blur of starlight called the Cygnus Star Cloud. Its light glows throughout the center portion of Cygnus the Swan. Continuing to move northward along the Milky Way, look outward, away from the galaxy's center. The number of stars drops off quickly, but there's still a lot of dust and gas between Earth and the next spiral arm. These dust lanes scatter themselves from Cepheus to Cassiopeia, and are considerably more delicate than the ones to the south.

Watching the sky rotate until dawn, we once again encounter increasing star density, nebulae, and clusters. Swinging into view is the Orion spiral arm, the continuation of an arm that included the Cygnus Star Cloud.

clusters that are easy binocular targets spanning 15' and 80'. For more northern, temperate observers these two clusters graze the southern horizon in the early evening, and a very clear horizon and atmosphere is required to see them.

Star clusters are about all you'll find in Scorpius this month, as most of the planets lie in neighboring constellations. Pluto glows dimly in Ophiuchus. Uranus and Neptune are fine binocular targets for the early evening in Capricornus and eastern Sagittarius. Neptune's pale blue disk is visible in a telescope, although the planet only measures 2" across and has a magnitude of 7.9; to its southeast you'll find the globular star cluster M75.

Uranus, on the other hand, maintains a reasonable magnitude 5.8, an easy binocular object lying to the south of the triangle of dim stars, Rho (ρ), Pi (π) and Omicron (o) Capricorni. Uranus's 3.6"-diameter disk and verdant hue make it easily recognizable in a telescope. A few consecutive nights of plotting the position of Uranus will show its westerly path against the background stars is slowing this month. At this time, Earth is moving directly away from Uranus. Within a few months we will swing around the sun and Uranus will be on the other side of the solar system.

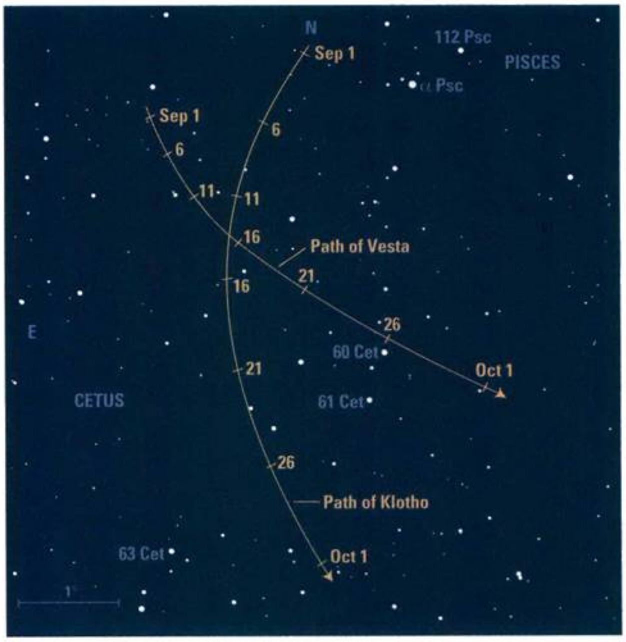
Far to the east of these fainter outer planets is Jupiter, the biggest planet in the solar system. It stands higher during the early evening relative to last month, when it reached opposition. Once Venus sets in the early evening, Jupiter is the brightest planet in the sky at magnitude –2.7, just a tenth of a magnitude fainter than its opposition brightness in August.

Many observers often forget that the largest of Jupiter's 16 moons, the Galilean satellites, are visible in 7x50 binoculars mounted on a tripod. A steadied view will reveal Io, Europa, Ganymede, and Callisto close to their bright planet. A small telescope makes the satellites easy to spot, along with a 6th-magnitude interloper star during the first few days of September. Notice the different appearance of the true moons and this star. The moons show tiny disks and don't twinkle like the star, which is a pinpoint of light.

As soon as darkness falls, Saturn makes an appearance on the eastern horizon, rounding out a collection of six outer planets visible at one time. The planet is unmistakable among the fainter stars of Pisces, shining at magnitude 0.2.

Through a telescope the rings of Saturn are inclined to the ecliptic by 27°, and since their edge-on view in 1995 they have been opening up to our view. Now we see

Close Encounters in the Night



All illustrations by *Astronomy*: Elisabeth Rowan

Asteroids 4 Vesta and 97 Klotho cross paths this month a couple of degrees from Alpha Piscis, the melding place of the delicate pearl-like chains of stars that highlight Pisces the Fish. From September 12 to September 16, the minor planets draw to within 25' of one another — less than the moon's apparent width.

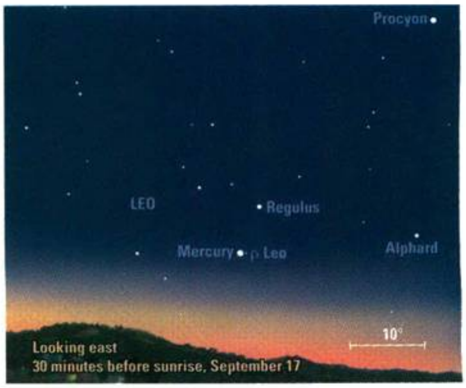
Vesta measures a respectable 300 miles across, compared to her diminutive suitor Klotho, ⅙th the size. It's no surprise that Vesta shines at magnitude 6.8 compared to Klotho's 10.8.

As its designation number suggests, Vesta was the fourth asteroid discovered, found on March 29, 1807. Klotho's discovery came more than 60 years later on February 17, 1868. Klotho takes its name from one of the three Greek Fates, Clotho, who presides over birth and spins destinies.

Vesta will be easier to see — like a damsel on a balcony — compared to Klotho's more undercover movements during the night. If you're not sure how to identify Klotho, make a sketch and compare it with one made another night to see which faint "star" moves.

Parting may be such sweet sorrow, but on the evening of September 26, Vesta brushes a mere 10" north of 5th-magnitude 60 Ceti, which should make you smile for such an easy observation.

Glimpse a Morning Mercury



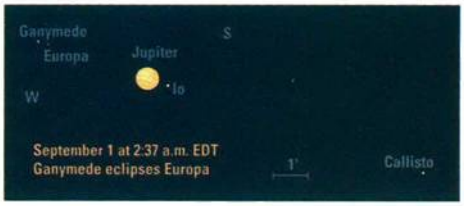
Looking east
30 minutes before sunrise, September 17

Mercury lovers can heave a sigh of relief. Mercury and the sun now rise at a decent morning hour. As opposed to what we see in the evening sky, the solar system stage in the morning is angled steeply to the eastern horizon.

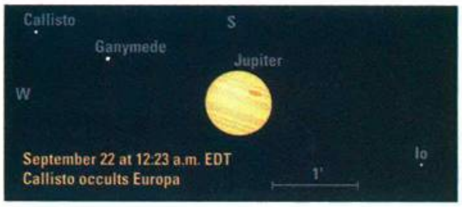
When Mercury reaches greatest elongation from the sun on September 16, much of that elongation gets translated into height above the horizon, thanks to the steep angle of the ecliptic. At magnitude 0.3 and 10° above the horizon when morning twilight starts, Mercury is relatively easy to find.

Check out its yellowish color in comparison to the blue-white of nearby Regulus. You can spot the Lion's heart about a binocular field, perhaps 5°, above Mercury. A greater challenge is to locate 4th-magnitude Rho (ρ) Leonis a half degree to the right of Mercury on September 17.

Comings and Goings around Jupiter



September 1 at 2:37 a.m. EDT
Ganymede eclipses Europa



September 22 at 12:23 a.m. EDT
Callisto occults Europa

There's always something fascinating happening on or around Jupiter, and this month offers a lot more than the ever-changing cloud belts and zones. The Galilean moons are eclipsing and occulting each other because their orbits are practically edge-on as viewed from Earth.

On Sunday evening, August 31, it will be worth staying up all night to ring in Labor Day Monday. At 2:30 a.m. EDT, Ganymede casts its long, dark shadow onto Europa, plunging half of Europa's icy face into darkness. The eclipsed Galilean satellite stands to lose a full magnitude of its brightness during this leisurely 26-minute event.

But the highlight of the month occurs on the evening of Sunday, September 21. A total occultation of Europa by Callisto only caps what's already an exciting evening for observers east of Texas and the Dakotas. They will also get to see two moons' shadows transit Jupiter's cloud-tops at the same time.

On other nights, pairs of moons will sometimes appear to travel tightly together, and occasionally pass in front of one another. A complete list of mutual occultations and eclipses for any viewing site in the world can be found on the Internet at: http://www.lowell.edu/users/ijw/mutualtable9698.txt.

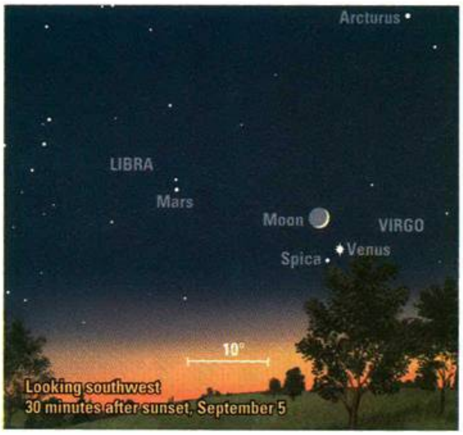
Meanwhile, Jupiter's 17th moon, the Galileo spaceraft, enters the waning weeks of a main mission that began in December 1995. An two-year extended mission slated to begin in December includes eight flybys of Jupiter's ice-moon Europa and one or perhaps two passes near the tiny, volcano-wracked moon Io.

Evening's Planetary Ballet

September's sky stage is set for a celestial waltz early this month that involves Spica, Venus, and Mars. The action takes place fairly close to the horizon because the ecliptic, the path which the moon and planets follow through the sky, lies low along a line from the sun through Sagittarius in the south.

On the evening of September 5, a three-day-old crescent moon slides to within a binocular field of the blazing Venus and the blue-white Spica. Try to catch the scene as early as possible to watch Venus and the moon move relative to Spica. By September 6, Venus and Spica are 1.7° apart, while the moon continues to close in on Mars.

Spica drops ever closer to the sun as Earth continues its pirouette around the sun opposite from Virgo. But Venus holds its ground with twilight all month; to earthbound viewers it simply hangs in the sky as background stars wheel slowly past. It will take several months before the evening "star" finally pulls ahead of us in its orbit closer to the sun and disappears into the solar glare. That won't happen, however, until well into 1998.



Looking southwest
30 minutes after sunset, September 5

their southern face giving us a better look at the fine divisions within the system. Look for the dark Cassini division, a feature easily seen in small telescopes. Observers with larger scopes may want to try for the harder-to-see Encke division, a tinier gap in the rings of Saturn.

On September 18, the moon occults Saturn, an event visible for most of the United States except for those observers in the northwest. This is the most spectacular event of any lunar occultation, and the most favorable for North Americans. Watching the moon slowly sweep over the rings and then the planet itself is a truly magnificent sight. It also provides a simple proof, as if one were needed, that Saturn is farther away than the moon. Once the planet's disk is occulted, you might still see what's left of the saturnian ring system sticking out from the dark lunar limb — a curious sight indeed, and one that is fleeting.

September is also an ideal month to sweep through the Summer Triangle with binoculars. The triangle, an imaginary shape made from joining three stars, Deneb, Vega and Altair, lies high overhead during the early evening hours. For the best views of this region of sky, take a trip to dark skies away from city lights.

The dark rift in Cygnus, a dark lane between two bright regions in the Milky Way caused by dust along the line of sight to those distant stars, is worth noting. Throughout Cygnus, tiny asterisms of three, four, or five stars create an impression of scattered diamonds on black velvet. Each one of these stars is a sun burning with a brilliance typically exceeding our own star. Vega, the brightest star

OBSERVER'S CHALLENGE: Meet Me at Pease 1

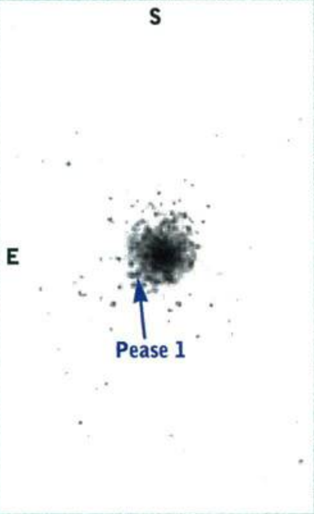
It's a pretty cool sight to catch two different types of deep-sky objects in the same field of view. Many *Astronomy* readers might be familiar with the easy duo made up of the planetary nebula NGC 2438 and star cluster M46, which sits behind it. Our challenge is to go a step deeper and spy the tiny planetary nebula Pease 1 inside the globular cluster M15.

There are five things you must do in order to achieve success: Use a clock drive, apply high power, view with a finder chart, wield a nebular filter, and most of all, have patience. Your scope can be modest — for most one with a mirror of 10 to 12 inches will do. Pease 1 has even been bagged by highly experienced observers with a 6-inch refractor. Skies are not a huge factor either; I've seen it when the naked-eye limiting magnitude was a lackluster 5.5.

Pease 1 lies a mere 25" north and 15" east of the concentrated core of this bright globular in Pegasus, a separation equivalent to the apparent diameter of Mars during favorable oppositions, but still quite small. This forces you to pump the power up past 200x to separate the stars. If the stars are not blurry, 300x-400x is more suitable. It scarcely needs to be said that without a drive you're well on the road to great frustration.

The accompanying photo can at first be misleading because the "V" pointing to Pease 1 at the upper left appears on the outer edge of the cluster. In reality this is only a 3-minute shot of the absolute core, unlike the typical 10- to 15-minute exposures that show myriad stars and a burned-in center. Look for the two trapezoids to help you sense the scale at the eyepiece and anchor your search. Take note: If you're using a diagonal on a refractor or Schmidt-Cassegrain telescope, photocopy the photo onto a transparency that can be flipped to match the orientation of your scope. Remember that a Newtonian inverts images, so you'll have to rotate the photo for use at the eyepiece.

Mace Hooley



Kim Zussman

Thirteenth-magnitude Pease 1 may not be obvious once you've star-hopped your way to the right spot. At 1" across, it appears practically merged with other stars. This is where a nebula filter gives you the upper hand; it allows you to "blink" for Pease 1. Light from the stars gets squelched while the planetary's light comes through unhindered. By flipping the filter into and out of your line of sight and comparing the views with and without the filter, you'll note one "star" stays lit. That's Pease 1.

To make this work, you'll need a high-contrast nebula filter like Lumicon's OIII filter. Use a dark hood over your head to block out stray light and maximize dark adaptation.

And remember: patience and more patience. It could take 30 to 45 minutes to make a firm identification. This is a small price to pay when you consider you'll see a planetary nebula that's physically part of a globular cluster. Good luck!

in the triangle, anchors the tiny constellation of Lyra the Lyre. Alongside Vega is Epsilon (ε) Lyrae, the famous "double-double" quadruple star system 200 light-years away. Observers with keen eyesight might spot it as a double with the naked eye. But it's only through a telescope that we see that each star itself is double. This is a particularly fine challenge for small telescopes.

South of Epsilon and Vega, look midway between the stars Sheliak (Beta [β] Lyrae) and Sulafat (Gamma [γ] Lyrae), the lower pair of stars in Lyra, for the Ring Nebula, M57. This tiny "smoke ring" is best found under low power in a telescope, but once found, looks best at higher powers. A 60mm (2.4-inch) telescope is large enough to pick out this object, though a good quality finder will help your quest enormously.

While in the area, keep an eye on Sheliak. Most of the time it is as bright as Sulafat, but occasionally it dips in brightness by 0.3 magnitude as it undergoes an eclipse. A companion star virtually touches Sheliak in an orbit that lasts 12.9 days.

Our companion moon reaches its full phase on September 16 to wash out many of the sky's subtle features. The full moon of September is called the Harvest Moon, and for good reason. On successive nights, the moon rises only some 30 minutes later each night around this date, instead of the usual 50 minutes. This is because the ecliptic, the moon's path, makes a shallow angle to the horizon. This effect means that on a number of nights around full moon, farmers can continue plowing their fields well after sunset, working by the light of the moon.

Harvest time signals the arrival of autumn. Astronomically, autumn's arrival is marked by the autumnal equinox, which happens on September 22 at 7:55 p.m. EDT. At that moment the sun passes south of the celestial equator, where it remains until the vernal equinox next March.

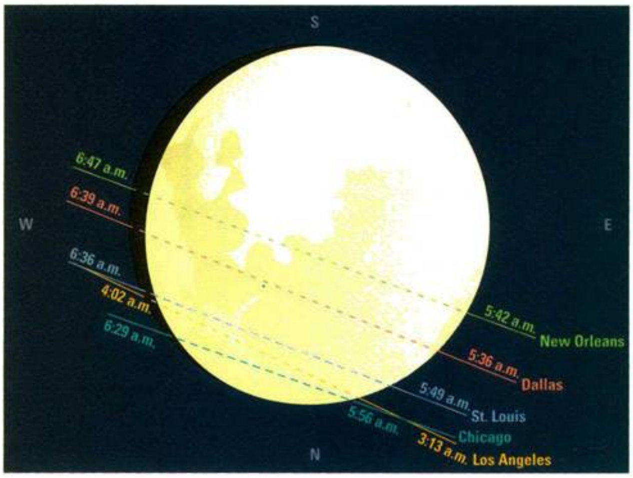
September offers us another view of an astronomical object on the move. Early risers using a small telescope might glimpse Comet Hale-Bopp as it moves south of Canis Major. For a couple of weeks in mid-September, northern observers get their last chance to view the comet before it becomes a solely southern hemisphere target.

Catch it just before morning twilight low in the southeast, far below Sirius. It will only be a couple of degrees above the horizon at the beginning of nautical twilight for mid-North American latitudes, with observers farther south faring better. The comet should be glowing at magnitude 5.

Also making a brief morning appearance is Mercury. It's growing crescent phase will be of interest to telescopic observers as the month marches on with maximum western elongation of 18° from the sun occurring on September 16. By the end of September Mercury will brighten to magnitude –1.2 in a twilit sky as its phase moves toward full illumination.

Martin Ratcliffe directs the Henry Buhl, Jr. Planetarium in Pittsburgh, Pennsylvania. Alister Ling is a meteorologist for Environment Canada in Alberta.

A Lunar Brush with Saturn



This month's highlight is without a doubt the lunar cover-up of Saturn. Except for observers in New England and the northwestern states, the rest of the country has box seats for this spectacular event at dawn on September 18.

Planetary occultations are drawn out when compared to disappearances of stars. They just wink out, whereas Saturn will be slowly swallowed. It could take up to a minute to disappear. If you live on a line from northern Michigan through Salt Lake City to just south of San Francisco, you get to observe Saturn slide through the valleys of the lunar north polar region. Any farther north and it's close, but no cigar.

These types of events do not occur all that often — typically on an 18-year cycle. When we're on the right part of the track, we can get several occultations during a year. However, sometimes the occultation occurs on the other side of the planet, or it's cloudy. Then there's a long drought, so it's worth getting up to see this one. The only other occultation of Saturn that occurs this years is on November 11/12, and that's only visible in the southeastern states.

A Dumbbell in Space

Scott Hicks

One of the world's favorite planetary nebulae rides high in the south on September evenings. M27, the Dumbbell Nebula, is a bright puffball of gas that shows up well in any scope and is within easy reach of binoculars outside city skies.

To find the Dumbbell, use the star map printed in the magazine's center to find the stars of Vulpecula the Fox. I've never been able to see a fox among the stars, but a capital M composed of 5th-magnitude stars shows up just above the brighter arrow of Sagitta. The Dumbbell lies just below the M's central, bottom star.

Unlike Pease 1 (see the Observer's Challenge box), you won't need special filters to spot M27. The Dumbbell's main shape is frequently described as an apple core, and sometimes as two triangles touching at the points. Scopes larger than 6 inches will reveal the two triangles as detailed wings.

These are lobes of gas puffed off 4,000 years ago by a star not unlike our own. At the very center of 8'-wide M27 is the magnitude 13.5 progenitor star, a harbinger of what's in store for the sun when it forms its own planetary nebula some 5 billion years from now.

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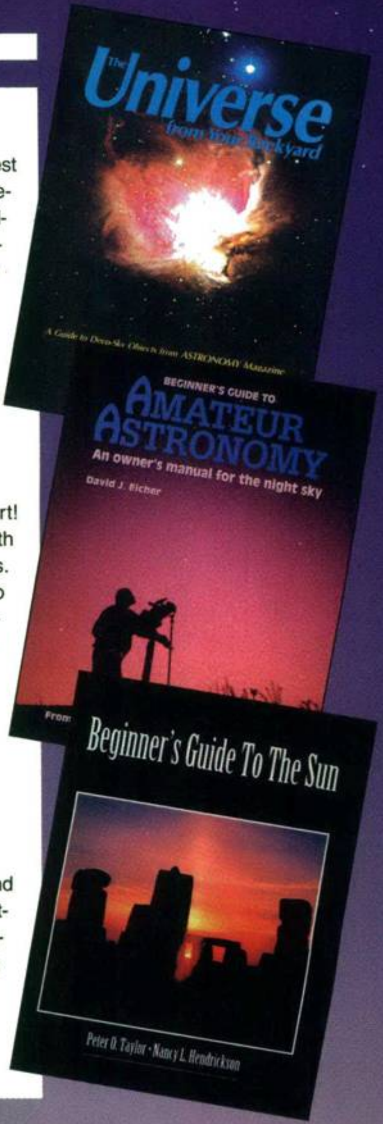
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Blue Sky Gazing

Did scarce summertime observing keep you inside nights? Carpe diem!

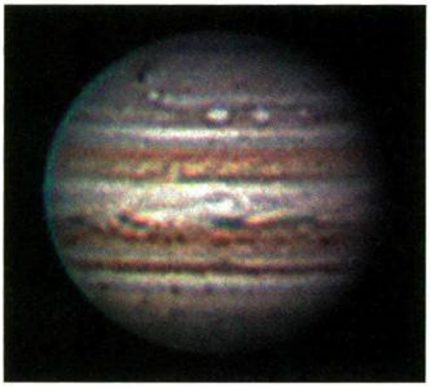
by Bob Berman

ASTRONOMERS HAVE JUST one problem with the warm weather period that runs from the spring to the fall equinox: There are far more daylight hours than those of darkness, and stars become as scarce as tasty supermarket tomatoes. In much of the United States, full darkness doesn't begin until after 10 p.m. local time.

Nights are brief, drowsy affairs more suited for insomniacs and rock musicians than the sensible, well-adjusted people backyard astronomers are known by all to be. The simplest solution? Forget the night. Find celestial treasures where few are seeking them — in the daytime sky. There are more than enough riches to elicit "Hey" while the sun shines, certainly enough to keep us busy until darkness falls.

This is especially critical if we're entertaining a scout group or other assembly of kids whose parents love the idea of a sky tour, but would rather see their loved ones tucked safely in bed before the zodiacal light announces the dawn. And no one gets the jitters waiting in line for darkness to fall.

Lovely Luna graces the sky above one of the many rock formations at Zion National Park in Utah (opposite page). Surprisingly, the brighter planets also make great daytime observing choices. Twilight sets the photographic stage for the trio on this page — Venus, Jupiter, and Mercury. Don Parker



Tom Polakis

Daytime observing is so neglected that you'd think skywatchers carried vampire chromosomes — and that's a shame because it's just as much fun and requires far less knowledge (no constellations to negotiate, for starters) than the nighttime version. Nor is equipment an issue during the daylight hours. Activities for naked-eye observing, for binoculars, and for telescopes abound, so that the hardware list boils down to whatever equipment you happen to have on hand.

Another plus is that most of the daytime phenomena you point out to your visitors are curiosities they have always seen but never fully comprehended, and which they now, in turn, can readily share with others. It keeps an upbeat astronomy message circulating like a chain letter from a benevolent planet.

Shades of Blue

The logical place to start is with the sky itself. Most people shrug it off as "blue," and that's that. But look at it more closely. The shade of blue actually varies in a predictable way, with the

deepest blue containing the juiciest objects to observe.

We've noticed since childhood that the sky gets lighter near the horizon, thanks to thicker atmosphere, dust, humidity, and pollution. What's interesting is that at ideal sites the horizon sky barely whitens. In other words, the degree of sky-brightening near your skyline is an excellent measure of the purity of your location.

Shortly before sunset, scan the entire sky and you'll notice a wide, curved belt of an especially deep blue that passes overhead and crosses the middle of the heavens. This darkest zone of the daytime sky, the area with the highest polarization, may be found 90° from the sun. The darkest sky naturally tends to hover around the zenith because that's where we look through the least amount of atmosphere, but this darkening effect is enhanced around sunrise and sunset when that overhead zone is also the region 90° from the sun. This double whammy conspires to produce an especially deep cobalt blue.

Even better, its high degree of polarization means that simple polarizing sunglasses, polarizing camera filters, or 1¼-inch screw-on polarizing eyepiece filters will darken it further, creating something approaching synthetic nighttime in this zone.

Happily, this sector of the heavens is precisely where the half-moon sits — the phase offering the best viewing of the month. At this time the lunar terminator directly faces the observer, placing optimally shadowed mountains and craters right beneath our eyes where they suffer their minimum foreshortening. It's the only time that perfectly illuminated craters appear round instead of elliptical.

The first quarter moon looks striking just before sunset because it's near its highest (in the south, within 15° of the meridian) and because it sits in that darkest section of the daytime sky. Bottom line: To observe the moon at this time, you only need a polarizing filter.

Day Stars

Venus and Jupiter are fabulous daytime telescope targets. Jupiter may be brightest and biggest now (its opposition was August 9), but daytime

Bob Berman

Antisolar rays, caused by parallel rays of sunlight poking through clouds, dominate a cool pink sunset (above). The blue-gray band on the horizon is the so-called twilight wedge, Earth's shadow. Sometimes, the twilight wedge appears starkly black. Just the right sun angle provides a dramatic display of antisolar rays (right).

observers get a "second coming" around quadrature, three months later, in November, when it sits in that darkest zone of the day sky. Venus, on the other hand, never appears in that dark district since it cannot wander more than 47° from the sun; instead it compensates with great brilliance (–4.4 magnitude at its brightest).

Admittedly, Venus isn't going to win any wows at the eyepiece except when it's a large beautiful crescent. Optimal appearances come at 19-month intervals and then it retains its good looks for about three months; next show — December.

Then you can easily find it with the naked eye by positioning yourself so that the sun is blocked by a tree or building. Count off four arm's-length clenched fists (each measures about 10°) to the upper left of the late afternoon or setting sun, and there it is.

Blocking the sun is necessary because your pupil constricts so much in direct sunlight you'd find it more difficult to see Venus pop into view against the blue sky.

Once you've found it, keep your eye glued its way and carefully walk while looking up (don't smash into that neighbor who is already observing your strange behavior) — and position yourself so that Venus seems to float directly above some prominent terrestrial landmark: a distant telephone pole, for example.

Once its location is fixed, you'll easily be able to show it to others by having them stand in your spot. You'll find viewers amazed and thrilled to see a "star" in the daytime. Its surrealistic crescent pops out with binoculars; a telescopic peek is icing on the cake.

During the month of its inferior conjunction (January 16, 1998) Venus achieves its personal best as an amazingly large, slender crescent whose sunlit sliver wraps more than 50% around its cloud-shrouded globe. Now binoculars become unsafe because their large field is likely to take in the nearby sun. It's telescope time.

Whatever magnification is used, you must view Venus against the day sky if you are to avoid the terrible turbulence near the horizon and escape the smudgy excessive contrast of its brilliance against the twilight sky. For best results, observe within a few hours of noon, when Venus is highest. If your scope has setting circles the job is easy. Otherwise, you'll have to mark off clenched fists from the sun, and carefully point the scope to the right spot.

As a teenager I sometimes got an accidental burst of the full explosiveness of the sun while "sweeping" for Venus; it's amazing I didn't end up as the first astronomer with a seeing-eye dog. Caution is essential: Through a telescope, the sun is so potent that whether you can turn away quickly enough once you've got an unexpected eyeful is iffy.

Sun and Shadow

Now that we've passed solar minimum and sunspots are returning, there's no excuse not to have a pair of $10 welders' goggles at hand or in the trunk of your car. Be sure you get shade number 14. Through them, naked-eye sunspots pop into visibility if they're Earth-sized or larger. If you're extremely careful, you can attach the goggles to the front of your binoculars, blocking the sunlight before it enters the objective lenses.

The sun, when viewed in this manner, is nothing less than awesome. But again, our attorney says we must advise you at least 17 times not to do this at all unless you attach them in a rigid,

Bob Berman

foolproof manner. Personally, I feel fine using a few extra-thick rubber bands to hold them in place in two separate directions — but please take no chances and double-check the rigidity of your setup before you even bring it outdoors. An inadvertent binocular sun-glance would deep-fry your retina; its telltale symptom is smoke wafting from your ears. And it's definitely a no-no to let kids handle any such homemade arrangement.

Suddenly, around sunset, when the sky's still bright, some of nature's greatest glories emerge. There's a lot to see in that twilight zone. First, do an about-face from the setting sun and observe the east. If unobstructed, the horizon will be hugged by an obvious thick gray band, which will slowly rise during the next half hour. You've seen it all your life and if you thought about it at all, you probably considered it the first blush of night.

Yet, look at it: Strangely, this is the only part of the sky where the bright twilight colors are absent, where a dark, somber horizontal band has invaded the heavens. What you're seeing is the twilight wedge — it's nothing less than Earth's shadow, thrown into space! Only now, within 15 minutes of sunset, are you on the correct part of Earth to be sighting cleanly along the edge of that shadow, which is why its upper margin is so sharply defined.

In just an hour it will be too late to observe the twilight wedge. You will have rotated more fully into the shadow and become immersed in it so completely that it rises higher and blurs, consuming your location and disguising its presence.

The twilight wedge is not subtle; it's there every clear evening of your life, and it allows you to gain points (with whomever) with your knowledge of nature's lesser known phenomena. When was the last time a shadow made you look so good?

Fairyland Photography

While you're facing east at that time, see if any converging bands of light meet at the twilight wedge. If so, you've spotted antisolar rays, which intersect at the point opposite the sun. These are rarer and therefore more interesting than the common crepuscular rays, whose Disney-like streamers radiate from the sunset itself.

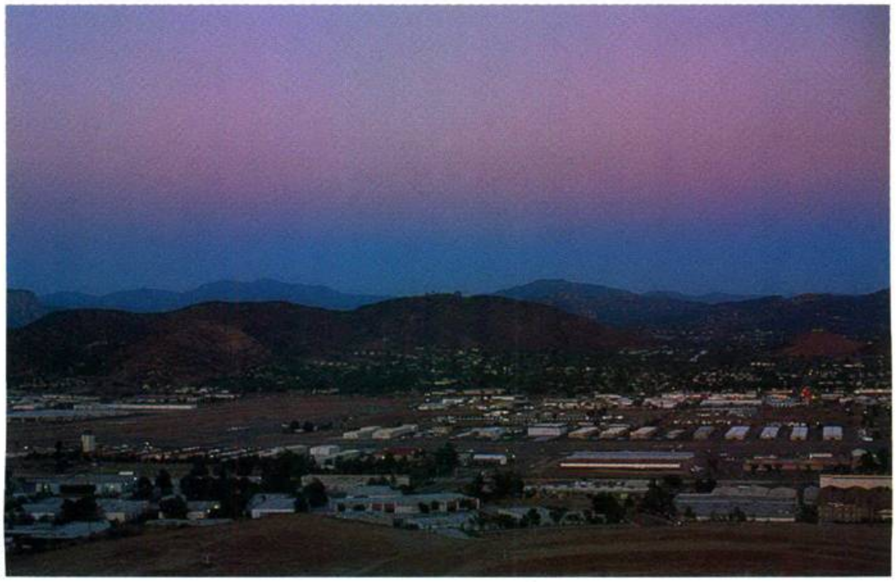
Caused by parallel beams of sunlight poking through distant clouds often beyond the horizon, the converging effect makes for beautiful fairyland photographs, especially when they're composed with good terrestrial foreground subjects.

Both phenomena appear somewhat similar, but photographs of them come out looking surprisingly different. Pictures of antisolar rays in the east at sunset will exhibit an illuminated foreground, while your photographs of crepuscular rays poking out of the sunset have earthly foreground objects show up as black cameos or silhouettes. So select accordingly; palm trees or cacti work well.

Unlike many natural phenomena that have been saddled with dry, technical terms, these twilight phenomena have been given names worthy of their beauty, names contributing to the magic of the event. Merely uttering such mellifluous phrases as twilight wedge or crepuscular rays convinces people that you can't be a bad person, and even influences the right companion to fall in love with you on the spot. Crepuscular, all by itself, (which means pertaining to twilight) should be used as often as possible, even when only marginally appropriate.

But I digress. For me, the most amazing daytime fact is also the simplest, and it explains things that we should have learned as children but didn't. To many people, twilight colors are thought to be somehow

Jerry Schad



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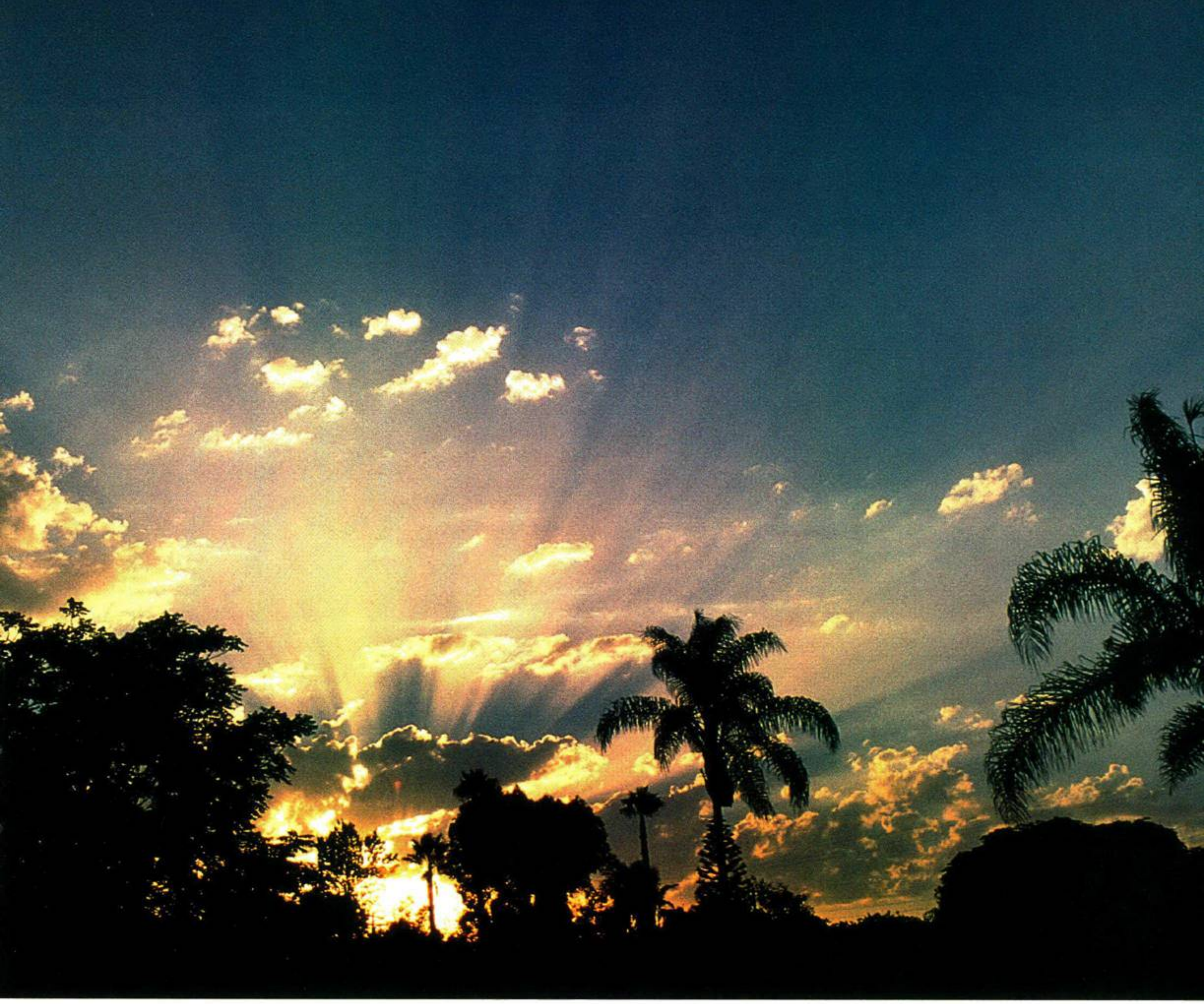
A twilight wedge glows in the eastern skies over El Cajon, California.



mysteriously produced by atmospheric *legerdemain*. But these are the actual colors of the sun!

The Sun's Color – Pure Light

In reality, the sun emits no white light; it radiates red and violet and green — all the colors of the spectrum. Many surfaces, such as clouds or sidewalks, reflect all the solar hues more or less equally, therefore they reach our eyes and brain together: The mixture is perceived as white. At sunset, it's another story. The varying path-length of sunlight through different thicknesses of the atmosphere refracts each color at distinct angles, and lets us see — side by side — the sun's true colors.

There's more. The blue firmament of day is caused by the shorter (blue) wavelengths getting scattered about into the atmosphere. But that blue color of the sky has to come from somewhere: It is light that has been robbed from sunlight en route to our eyes. In other words, the sun and sunlight that we see is missing some of its blue, which is why we think of the sun as lemony-colored.

Although it's a pure white star it seems yellowish because its white light has had some blue subtracted. This intimate but seldom-realized tie-in between the color of the sun and the blue sky is both amazing and obvious.

So even here, standing under the day or twilight sky — facing our own million-mile-long shadow or gazing at the half-moon against a deep but variable cobalt blue — we receive colorful instruction in the mechanisms of nature. What gifts these visual and conceptual realities are; surely every bit as grand as those to emerge with the coming darkness. ■

Crepuscular rays dart above the clouds and scatter into the sky. The brilliant rays emerge from the sunset and appear projected into the heavens above southern California.

Bob Berman, author of Secrets of the Night Sky, *is director of Overlook Observatory near Woodstock, New York, and Storm King Observatory at Cornwall, New York. He hosts a weekly "Sky Window" National Public Radio program.*

ask Astro

Q: Will Hale-Bopp give us a meteor shower? — *Phil Swanson, Estherville, Iowa*

A: Comet dust is the source of most meteors. In Comet Hale-Bopp's case, up to 100 tons of material erupted from the comet's nucleus every second. Much of this stuff was grains of dust. But not all dust belched by comets into interplanetary space goes on to become meteors in our atmosphere.

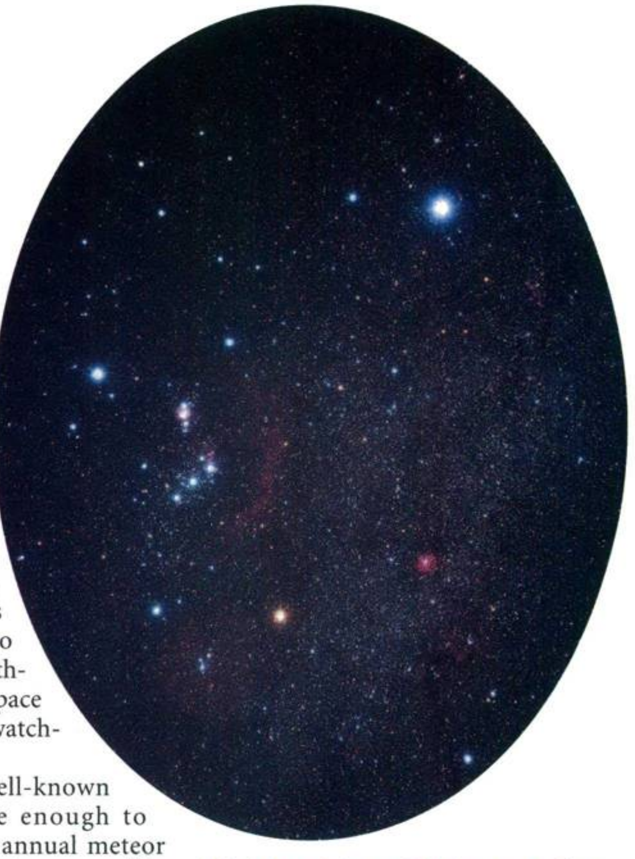
For that to happen, Earth must sweep the dust up along its orbit around the sun. This means the dust ejected along the comet's path must meet up with Earth's orbit. Unfortunately, Hale-Bopp's orbit does not intersect Earth's, so all that dust will be nothing more than wasted space junk as far as meteor-watchers are concerned.

Incidentally, two well-known comets do pass close enough to Earth's orbit to create annual meteor showers. Comet Halley is responsible for October's Orionids and May's Eta Aquarids. Comet Swift-Tuttle churns dust out for the famous Perseids, which stargazers enjoy every year around August 12. — *John Shibley*

Hale-Bopp won't spawn a meteor shower. The comet's path carried it north of the sun, well out of the plane of Earth's orbit. This photo shows the visitor on April 5, 1997, when its blue gas and yellowish dust tails opened against the constellation Perseus the Hero. Loyd Overcash

Q: If I were standing in, say, New Zealand, and viewed a familiar constellation like Orion, how would it appear compared with the view from mid-northern latitudes? And would the moon's face look the same as it does from up north? — *James M. Glasow, Hockessin, Delaware*

A: From the Southern Hemisphere, any object or constellation that lies anywhere near the celestial equator would appear both upside down and reversed left to right compared with our northern perspective. (Of course, people who live south of the equator think it's the northerners' view that's upside-down!)



This is how Orion and Sirius appear from Australia, where the image was taken. Luke Dodd

Orion makes a good example. Ruddy Betelgeuse lies at the northeastern corner of the Hunter's torso, while blue-white Rigel lies at the southwestern corner. From the Northern Hemisphere, observers have to look toward the south to see Orion, and therefore the southern part of the constellation appears closer to the horizon. And when facing south, east is to the left. Thus observers see Betelgeuse at the upper left of Orion and Rigel at the lower right.

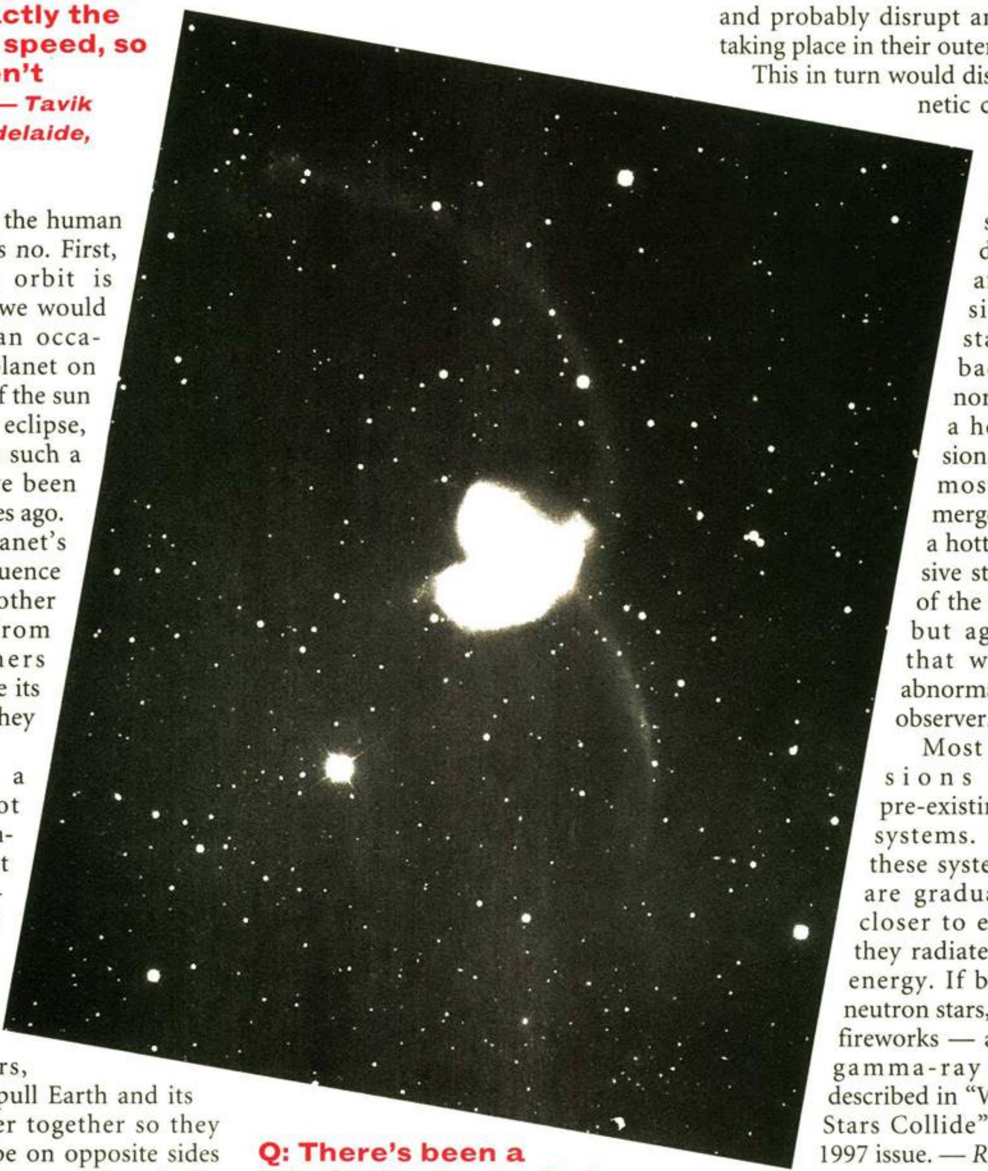
Now think how this would look from the Southern Hemisphere. From there, Orion appears in the north, so it's the northern part of the constellation that lies closest to the horizon. And when looking north, east appears to the right. So the Orion seen from the Southern Hemisphere has Betelgeuse at the lower right and Rigel at the upper left. The same geometry holds true for the other constellations as well as for the moon and planets, proving what a topsy-turvy world we live on. — *Richard Talcott*

Q: Is it possible that another small planet revolves on the other side of the sun, in exactly the same orbital plane as Earth, at exactly the same orbital speed, so that we haven't detected it? — *Tavik Morgenstern, Adelaide, Australia*

A: Fortunately for the human race, the answer is no. First, because Earth's orbit is slightly elliptical, we would always manage an occasional peek at a planet on the opposite side of the sun — during a solar eclipse, for example — so such a planet would have been discovered centuries ago.

Second, the planet's gravity would influence the orbits of the other inner planets. From this, astronomers could easily deduce its existence even if they couldn't see it.

Third, such a planet could not exist for long. Planets are not just subject to the gravitational influence of the sun, the planets tug upon one another as well. Over millions of years, these tugs would pull Earth and its counterpart closer together so they would no longer be on opposite sides of the sun. Being in approximately the same orbit, the two planets would eventually either collide (which would be very bad news for living creatures on both planets!) or the two would come close enough together that one or both of them would be gravitationally thrown into different orbits (which would also be bad news). This event would have already taken place, as it would happen in a time span much shorter than the age of the solar system. So we humans have lots of things to worry about, but this is not one of them. — *Robert Naeye*



This image of NGC 4038 and 4039 (the Antennae) shows a galactic collision. Stellar collisions have less spectacular consequences. Kitt Peak National Observatory

Q: There's been a lot of talk about what happens when galaxies collide, but what about stellar collisions? What kind of phenomena would be associated with those collisions? — Phillip Wynn, Minneapolis, Minnesota

A: Collisions between stars are extraordinarily rare. Stars are typically separated by such immense distances that even when two galaxies collide, the chance of any two individual stars colliding is remote.

But when two stars do collide, the end result is usually less spectacular than one might think. In a grazing collision (the most likely scenario), the two stars will raise tides on each other and probably disrupt any convection taking place in their outer atmospheres. This in turn would disturb the magnetic cycles and star spots occurring on their surfaces. But several hundred years after the collision, the two stars would be back to their normal states. In a head-on collision, the two stars most likely will merge. This creates a hotter, more massive star than either of the original stars, but again not one that would appear abnormal to a distant observer.

Most stellar collisions occur in pre-existing binary star systems. In some of these systems, the stars are gradually drawing closer to each other as they radiate gravitational energy. If both stars are neutron stars, you'll get real fireworks — and perhaps a gamma-ray burst — as described in "When Neutron Stars Collide" in the April 1997 issue. — *R. T.*

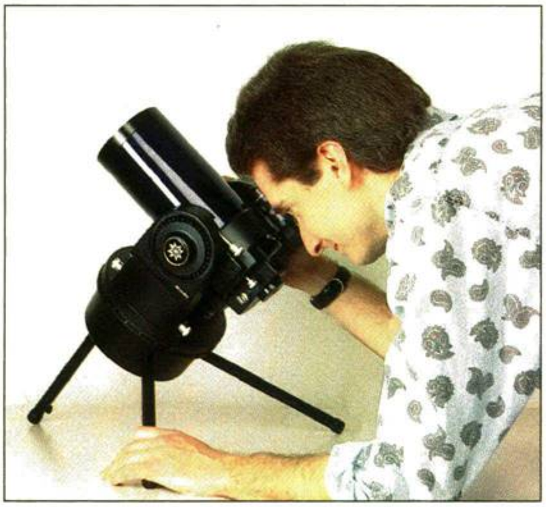
Is there a question about astronomy that's been gnawing at the back of your mind? We'd like to hear it! We welcome questions pertaining to both the science and hobby of astronomy. Send your query via e-mail to askastro@astronomy.com; or write to Ask Astro, P.O. Box 1612, Waukesha, WI 53186. Please tell us your full name and where you live. *Astronomy* regrets that due to the large volume of mail, we are unable to publish answers to all questions or respond to each one individually.

TABLETOP STAR CRUISER

Meade's ETX puts portable performance practically in the palm of your hand.

by Steve Edberg

28mm LP MULTI-C
MEADE



Meade's ETX telescope props up on three legs for quick and easy observing from a tabletop.

Small-aperture scopes seldom produce a hobby-wide splash when they come to the market. But when the 3.6-inch Meade ETX telescope first appeared in advertisements and started shipping to dealers last year, splash it did. Why? Many couldn't resist comparing it to the legendary Questar telescope, which the ETX echoes both in aperture and focal ratio.

Since the mid-1950s, Questar has been the portable scope of dreams. Its razor-sharp Maksutov optics offered up the best performance of any scope in its class, but at a steep price. Now, more than four decades later, comes Meade with the ETX for a song. And the ETX measures up, both mechanically and optically.

The store-bought unit that I tested for this story is the telescope I come back to most often. Its high optical quality and ease of set-up — turn on the drive, attach it to a permanent pier in the back yard, and aim it — makes it ideal for quick observing sessions or to check sky conditions before hauling out a big telescope. Best of all, the ETX travels easily and is a good instrument for eclipse chasing and vacations. These attributes alone make it a worthy successor to the Questar legacy for a fraction of the cost.

First Date under the Stars

To see how well the ETX's optical quality stacked up, I aimed at Mintaka, the westernmost of three belt stars in Orion. The 2nd-magnitude test star's image showed up as a clean Airy disk surrounded by a bright, first diffraction ring, which in turn was surrounded by successively fainter rings. This was to be expected, considering the ETX's secondary measures 30% of the main mirror's diameter. Obstructed optics always shunt a portion of the image's overall light into the first diffraction ring that surrounds an in-focus Airy disk.

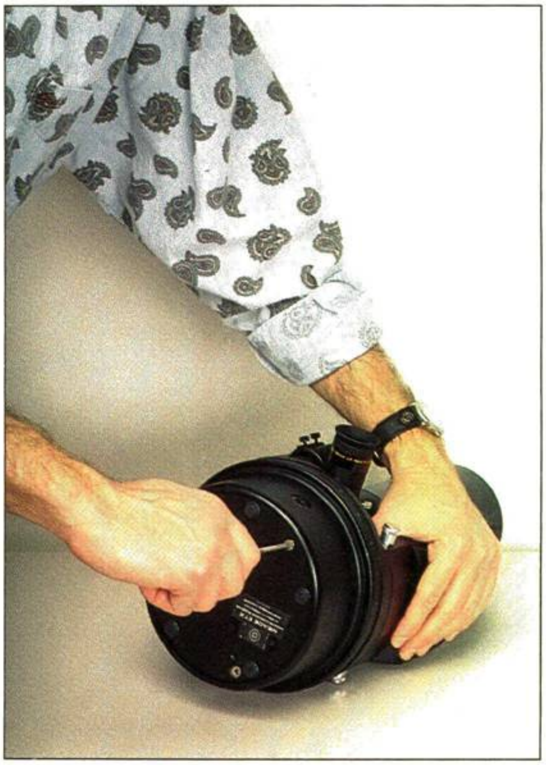
Two knobs directly underneath the eyepiece flip a mirror for viewing with the diagonal or straight through. Other knobs lock down or offer slow-motion control for each of the mount's axes.

Later that same evening I panned over to the famous "double-double," Epsilon (ε) Lyrae, to see how well the 90mm spilt double stars. Each star in the quadruple star system resolved cleanly into a distinct Airy disk surrounded by a tight diffraction pattern. The next night the ETX showed me a first quarter moon in luxurious detail. Features along the terminator snapped into sharp focus at 175x; rich blacks in the shadowed floor of each crater attested to the ETX's ability to handle glare from adjacent, sunlit portions of the moon.

All these evaluations took place during the cool temperatures of spring, usually in the 40s. I found the ETX cooled down from an indoor temperature of around 70° F to ambient in about 20 minutes. That's when tube currents inside the ETX's tube assembly died down to reveal the steadiest views. After that, whether observing the moon or star clusters, the 90mm's optical performance was outstanding, regardless of the target.

This optical quality comes in a package that's tough to beat. For tabletop use, simply screw in the three legs Meade provides: two in the side of the cylindrical base and a third, adjustable latitude leg into a hole in the metal base plate. The adjustable leg is conveniently marked for latitudes between 27½° and 42½°, and props the scope up so its polar axis will point at the North Star. The instruction manual also tells how to handle settings outside the leg's range. Beware, though — there is a tipover risk if the latitude leg is fully extended.

Get to the batteries by unscrewing a metal base plate.



All photos *Astronomy*: Rebecca Saliture

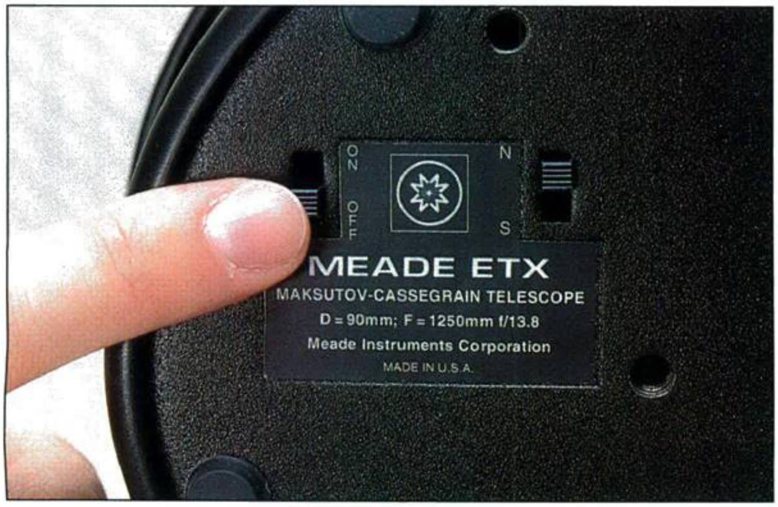
The telescope's tripod seems sturdy enough to support the scope, but a flimsy table underneath might make for a frustrating, vibration-filled observing session. Of course, the same would be true if the telescope were mounted on a flimsy photo tripod. If you do use the ETX on a tripod, make sure it's centered over the tripod's legs. Even my expensive (and sturdy, I thought) Bogen tripod wasn't adequate when completely extended. The scope does fit on a standard Schmidt-Cassegrain tripod, and it will also work with a wedge if you supply a ¼-20 bolt or male knob. Keep in mind that the ETX's design is really optimized for the simplicity of tabletop, clock-driven observing.

Lean, Mean Observing Machine

This points up one attractive feature the ETX offers — its potential as a compact astrophotography telescope. The rear cell accepts a camera adapter with threads that match spotting scopes on one end and standard T threads on the other. The length of the adapter and size of the camera will limit how far north you'll be able to photograph. A short adapter would make the scope more efficient for certain kinds of astrophotography. Photographers should also be aware that the T-stop (which measures the actual light transmission of the telescope) is T/18, much slower than the stated f-stop of f/13.8.

Solar eclipse chasers will appreciate how easily the ETX changes from eyepiece to camera, as I found during the March lunar eclipse. A 90° flip of a knob on the rear cell is all that's necessary. Unfortunately, the focus position for camera and eyepiece are significantly different. I used 1.25-inch chrome plumbing extensions to make a pair of tubes that raised the eyepiece high enough for both the camera and eyepiece to share the same focus. The focus knob on my ETX does turn a bit roughly, but this doesn't affect getting a good focus.

Identical switches built into the base plate toggle power on and off and switch the drive direction between northern and southern hemispheres.


ON
OFF
N
S
MEADE ETX
MAKSUTOV-CASSEGRAIN TELESCOPE
D = 90mm; F = 1250mm f/13.8
Meade Instruments Corporation
MADE IN U.S.A.

STANDARD SPECIFICATIONS

Aperture: 3.6 inches (90mm)

Focal ratio: f/13.8

Focal length: 1250mm

Secondary mirror obstruction (by diameter): 30%

Length of tube: 11 inches

Size of eyepiece holder: 1.25 inches

Included 1.25-inch eyepiece: 26mm (Plössl, 48x)

35 mm photographic field: 1.1° by 1.6°

Weight of tube assembly and fork mount: 9.2 lbs

Warranty: One year, materials and workmanship

Typical retail price: $595

(Includes 8x21 finder and tabletop tripod.)

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16542 Millikan Avenue, Irvine, CA 92606;
phone, (714) 756-2291; fax, (714) 756-1450;
website, http://www.meade.com.

Available through Meade's dealer network.

It's unfortunate that Meade doesn't include a travel case for this, one of the more portable scopes in its line. With cut-outs and foam in appropriate places, the sturdy cardboard box ETX ships in seems durable enough for storage and transportation. The box's outright size, however, might be one drawback for some people who travel light. If you're getting a telescope like this for convenient, go-anywhere use, you might want to buy a more compact storage case. Meade offers one that is rectangular and padded on all sides with a zipper opening along the top. A single side pocket inside holds the ETX's standard accessories like the table-top legs and a 26mm Super Plössl eyepiece, with room for more stuff. For still more room, consider a standard camera or camcorder bag available from any photo retailer. I found that the Meade padded case traveled comfortably under an airline seat and over the shoulder on a flight to Tucson in March.

Another thing that caught my eye soon after I unpacked the scope was the significant amount of plastic Meade used in its construction. The fork arms, mirror cell assembly, and clock drive base are all made of metal-reinforced ABS plastic, except for the mount's base plate. Overall, the ETX is bulkier than the more-expensive Questar simply because plastic needs to be thicker than metal to adequately support the telescope. The plastic parts do not detract from the instrument's performance, and the metal base plate does keep the telescope's center of gravity low for greater stability.

The Devil in the Details

My first task after reading the directions (which I recommend) was to install batteries. While a Questar requires an external power supply, Meade's ETX will operate for many hours on three AA batteries. To install them, the metal base plate must be removed by taking out three Phillips-head screws. Getting to the battery compartment would be easier if Meade had used thumbscrews.

The power and north/south hemisphere selection switches poke through the bottom base plate. While they are clearly marked, the switches feel the same to the touch. If they felt different, it would be easier to find the power switch in the dark, instead of guessing which switch is which. Such a change might add slightly to the ETX's base price, but it would be worth it.

I'd also be willing to accept a slight loss in battery lifetime if the drive had an LED indicator light. Such a light would indicate whether the drive motor was on and working. The only way of determining that now is to place an ear next to the base to hear if the motor's humming. On at least one occasion my hearing failed me: I found the batteries drained before starting one observing session — apparently I had left the drive on after the previous session. An LED would have reminded me to turn the drive off before packing up.

After plunking the ETX on a tabletop, you'll want to polar align it with the north celestial pole. First, lock the declination at 90°. The declination scale is easy to read and there is a pointer molded into each fork tine. After locking the declination with a thumbscrew, slide the ETX left and right and adjust the latitude leg up and down until Polaris centers in the main scope's field of view.

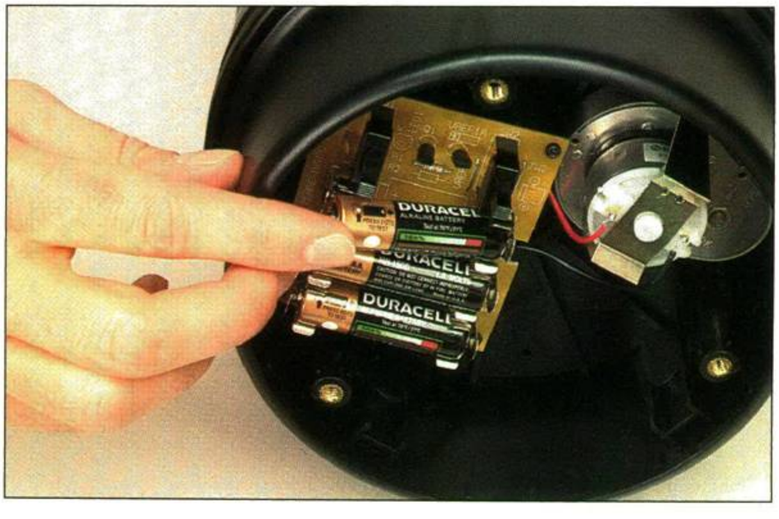
Don't count on using the ETX's 8x21 erect-image finder during polar alignment; its placement on the optical tube assembly and size make it impossible to use when the declination points to 90°. I had to locate Polaris by adjusting the mount and looking through the main scope. This was a challenge with the 1° field of view afforded by the 26mm eyepiece that came with the telescope.

After aligning, it was time to collimate the ETX's finder with the main telescope. Because the finderscope is mounted so close to the main tube, I have difficulty getting my cheek close enough to it for a comfortable view. Even collimating the finder was difficult because alignment thumbscrews were so close to other parts of the tube assembly. It was hard to work my fingers in such tight spaces for loosening or tightening the screws. After a few minutes of adjustment, though, the finder scope was aligned and ready to help me land targets.

The ETX sets up on a heavy-duty photo tripod for use as an altazimuth telescope.

But these minor points hardly detract from areas in which the ETX excels. Nothing but the vaunted Questar comes close to matching the portability and optical quality I found in this telescope. A better 90mm Maksutov scope would be the Questar itself — at five or six times the ETX's asking price. So here's a parting piece of advice: Stick with a less-expensive alternative and bank the money you save for an eclipse expedition. ■

Steve Edberg has been test-driving telescopes and making his own for 30 years. He also directs the Riverside Telescope Makers Conference, a star party held Memorial Day weekend in the mountains above Los Angeles.



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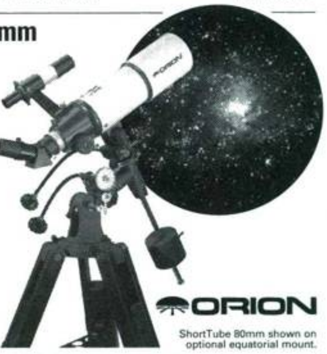

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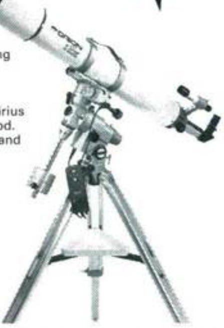

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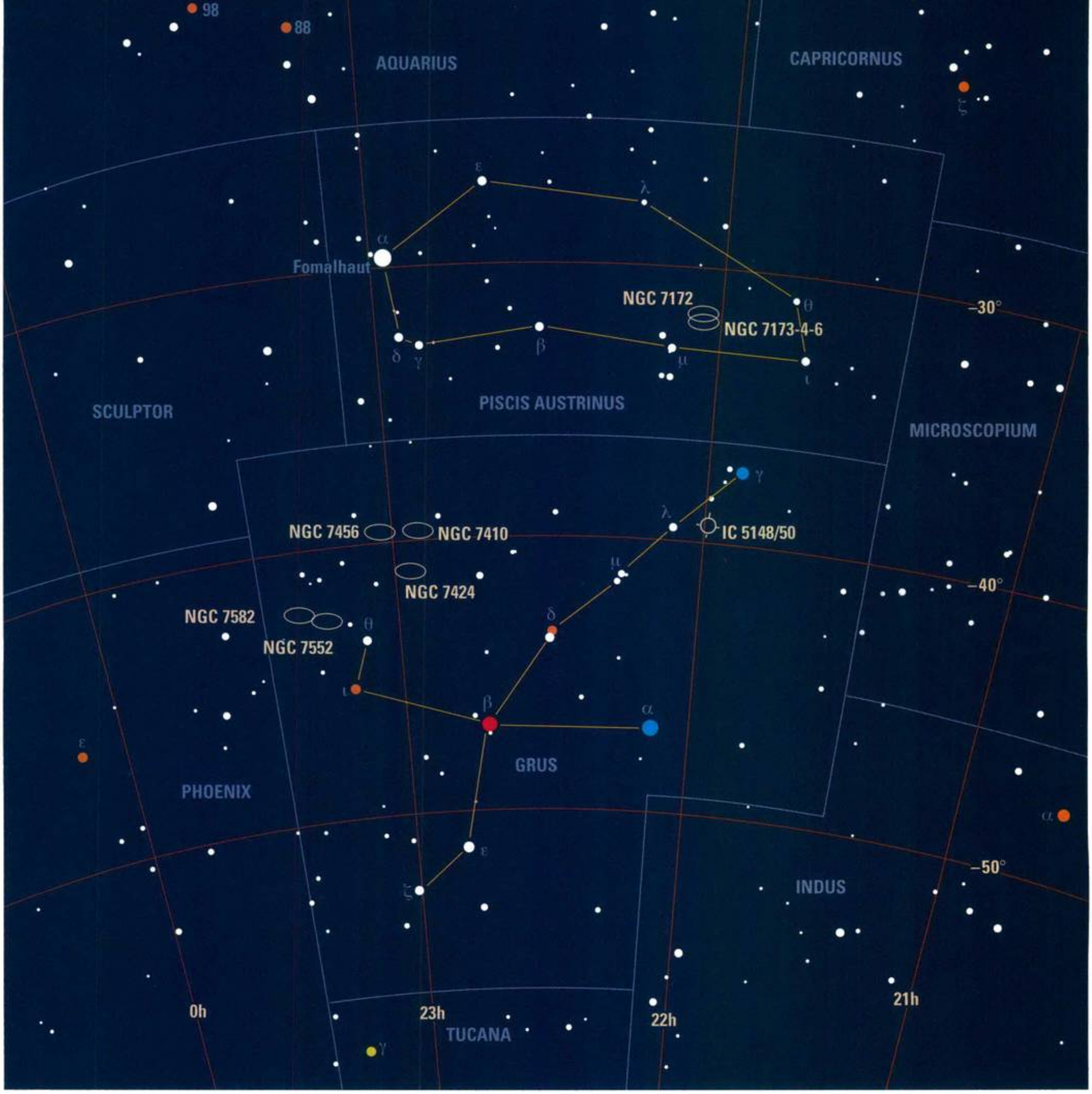
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Astronomy: Theresa Metzger

Sweeping the Bottom

For Northern Hemisphere observers, two southern constellations offer off-the-beaten-path galaxies.

by Richard Jakiel

Take time to "scrape the horizon" and you will find some pretty out-of-the-way areas of the sky. Much of the region below the bright star Fomalhaut is visually dull, and many people don't know the names of the constellations let alone the telescopic treasures hidden there. Yet, a celestial tour of Piscis Austrinus and Grus reveals a wealth of fairly bright objects.

Our first stop is the brightest star of the southern autumn sky — Fomalhaut in Piscis Austrinus the Southern Fish. At magnitude 1.2, it almost overwhelms the dim stars of surrounding constellations. This celestial show-stopper provides a handy starting point to lesser known sections of the southern sky. Star-hopping from Fomalhaut to the western half of its constellation, we find several small groups of 11th- to 12th-magnitude galaxies.

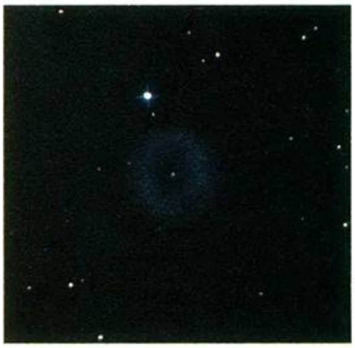
By far the nicest is the **NGC 7172 galaxy group,** which includes **NGC 7173, NGC 7174,** and **NGC 7176,** about 1.5° northwest of Mu (μ) Piscis Austrinius. Also known as Hickson 90, the group belongs to a catalog of galaxies that includes such famous groups as Seyfert's Sextet and Copeland's Septet. This tight knot of 11th-magnitude galaxies should easily fit in the field of view of a medium- to high-power eyepiece.

NGC 7174 and NGC 7176 are so close that they share a common envelope, while NGC 7173 lies only 1' to the north. The largest of the group, **NGC 7172,** is a fairly bright, oval galaxy a scant 6' north of the main knot. It's unfortunate that this tight little group lies so far south since it is a much more impressive sight than the better known Seyfert's Sextet.

Nearly 8° south of Hickson 90, in the obscure constellation Grus the Crane, lies one of the most neglected large planetary nebulae in the sky — **IC 5148/50.** This nebula appears as a pale, ghostly ring about 2' in diameter set against a nice star field. At magnitude 11, it is fairly bright and responds well to both UHC and OIII nebula filters. Seen through a small telescope, it bears a considerable resemblance to the famous Helix Nebula (NGC 7293) in Aquarius. California observer Steve Gottlieb describes the planetary as "one of the finest of its type in the sky." Perhaps, in time, IC 5148/50 will earn a nickname like other showpiece planetary nebulae. How about the "Ghost-Ring Nebula?"

Object	**R.A. (2000.0)**	**Dec.**	**Mag.**	**Size**
IC 5148/50	21h59.5m	–39°23'	—	120"
NGC 7172	22h02.0m	–31°52'	11.9	2.2' by 1.3'
NGC 7173	22h02.1m	–31°59'	12.1	1.3' by 1.1'
NGC 7174	22h02.1m	–31°59'	12.6	1.3' by .07'
NGC 7176	22h02.1m	–31°59'	11.9	1.3' by 1.3'
NGC 7410	22h55.0m	–39°40'	10.4	5.5' by 2.0'
NGC 7424	22h57.3m	–41°04'	10.9	7.6' by 6.8'
NGC 7456	23h02.1m	–40°50'	11.9	5.9' by 1.8'
NGC 7552	23h16.2m	–42°35'	10.7	3.5' by 2.5'
NGC 7582	23h18.4m	–42°22'	10.6	4.6' by 2.2'

This table provides designations for selected celestial objects in the constellations Grus and Piscis Austrinus, as well as positions in right ascension and declination, visual magnitudes (Mag.), and sizes in arcminutes.



Jack Marling

One of the more challenging members of the constellation Grus, planetary nebula IC 5148/50 glows only faintly as seen with small scopes.

Grus also has a fine collection of galaxies. Many of them belong to the Grus Galaxy Cluster which extends into the nearby constellations of Phoenix and Sculptor. More than two dozen 10th- to 12th-magnitude galaxies are associated with this cluster. These are as bright as many of the Messier galaxies in the Virgo Cluster.

We'll start exploration just across the Grus-Piscis Austrinus border. Here begins the northern extension of this galaxy cluster. The galaxies **NGC 7410, NGC 7424,** and **NGC 7456** comprise the brightest members of this small clump, each being 11th-magnitude or brighter. Both NGC 7410 and NGC 7456 are elongated objects with bright nuclei. The latter galaxy is a nice spindle-shaped object, measuring about 5.9' by 1.8'. NGC 7424 is a large face-on spiral galaxy, similar in structure to the Pinwheel Galaxy (M101) in Ursa Major. One of the brightest and largest members of the cluster, NGC 7424 shines at magnitude 11.0 and measures a respectable 7.6' by 6.8' across. Observations with my 13-inch scope reveal a large, nearly round soft glow with a small condensed core.

Near the bright double star Theta (τ) Gruis, the main concentration of galaxies shifts from a north-south orientation to an easterly one. Here lies the most famous group of galaxies in this part of the sky — the Grus Quartet, a beautiful grouping of bright spiral galaxies. At magnitude 10.6, **NGC 7582** is the largest and brightest member of the group. The scope revealed this galaxy as a soft, fuzzy ellipse measuring about 6' by 2'. It has a bright core and hints of structure are visible in the diffuse outer envelope. Nearly as large and bright is nearby **NGC 7552.** This magnitude 10.7 oval has a brilliant stellar core. The last two members of this small group are also highly tilted ellipses, each being objects of 11th magnitude.

Many more galaxies can be found farther to the east in Sculptor, Fornax, and neighboring constellations. If you have access to a deep southern horizon, take the time to explore these lesser known wonders in Piscis Austrinus and Grus — they are well worth the time and effort.

Richard Jakiel's last article, "Southern Skies Horde the Giants," appeared in Astronomy's *May 1997 issue. He is a radiochemist living in Atlanta, Georgia.*

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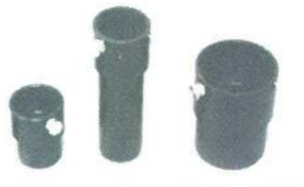

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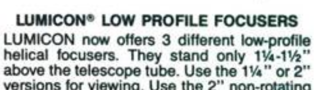

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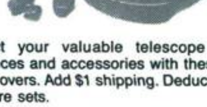

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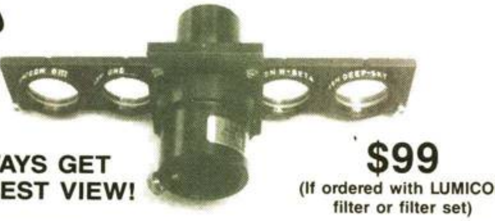

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8, 11, 15mm Plossl . **$95**, 20, 25mm	**$105**
32mm Plossl, widest true field in 1¼"	**$125**
55mm 2" Plossl, widest possible field	**$235**
2.0x or 3.0x Tele Vue Barlow Lens	**$119**
2" Giant Barlow - 2x	**$185**
15mm Wide-Field, 1¼" eyepiece, 65°	**$139**
4.8mm Nagler, 82° field, 1¼" eyepiece	**$175**
7mm Nagler, 1¼" eyepiece, 82° field	**$225**
9mm Nagler, 82° field, 1¼" or 2"	**$245**
13mm Nagler, 82° field, 1¼" or 2"	**$315**
12mm Nagler, Type II, 82°, 1¼"/2"	**$295**
16mm Nagler, Type II, 82°, 1¼"/2"	**$315**
20mm Nagler, Type II, 82°, 2" only	**$395**
2" Paracorr Visual Coma Corrector	**$259**
15mm Panoptic 1¼", 68° field	**$215**
19mm Panoptic 1¼", 68° field	**$245**
22mm Panoptic 1¼"/2", 68°	**$285**
27mm Panoptic 2", 68° field	**$335**
35mm Panoptic 2", 68° field	**$365**

TeleVue Warranty may not be valid outside USA.

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback *mount* is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
***LUMICON Adjust.* Piggyback Mount $59.50**
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

Specify Lens Size	H-Alpha	(DS)
46, 48, 49mm	$59.00	$199.50
52, 55, 58, 62mm	$69.00	$199.50
67, 72, 77mm	$79.00	$399.50
82mm (77mm + adapter)	$89.00	$415.00

Hypered 2415 film, 36 exp .. **$11.95, $3/$32**

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NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$189.50**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain."
***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

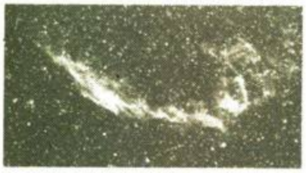
"Consistently performed well on all emission and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE*, July 1995**

BETTER THAN A DARK-SKY SITE!?

"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE*, July 1995**

SEE THE HORSEHEAD!

*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . ."* ***SKY & TELESCOPE*, July 1995**



"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

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48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	**$199.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	**$199.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16)	**$399.50**
2" Rear Cell Filter, fits SCT's ... Deep-Sky, **$199.50** UHC, O-III, H-Beta,	**$199.50**
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	**$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	**$199.50**
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LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** ... **$99.50, 48mm**	**$199.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines ... **1¼" $99.50; 48mm**	**$199.50**
LUMICON Comet (Swan band) Filter ... **1¼" $99.50; 48mm**	**$199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	**$7.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	**$19.50**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	**$25.00**

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

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LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$75**

Electric Vacuum Pump, Model R-10 **$325**

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All **LUMICON EASY-GUIDER™** off-axis guiders⁶ have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. ⁶U.S. Patent 4,448,500
Specify Camera and Telescope type.

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Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$189.50**
48mm Coma corrector/field flattener	**$285**
3X Relay Diagonal (see photo)	**$99.50**
Illuminated reticle eyepiece, pulsed	**$109.50**

Guider for Hasselblad **$489,** Mamiya 645 **$259**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

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For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

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For Celestron-11, C-14, and the 10-12" Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

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Adapter for Hasselblad **$399,** Mamiya 645**$149**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** ... **$109.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.

2. **Cable release** for long exposures . **$9.95**

3. **Declination motor** (state telescope type) **$109**

4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.

5. **LUMICON EASY-GUIDER** (selection to left)

6. **LUMICON 48mm DEEP-SKY FILTER $199.50**
This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.

7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

TRY PPF! HYPERSENSITIZED FILM

TP 135-36
SR1600
Scotch
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HYPERED FILM IS 2-10X FASTER!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	Exposures	Price
Kodak PPF-400, THE BEST!	36	**$14.95**
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Gold 1000 fast, fine grain	12	**$13.95**
Fuji G800 fine grain color neg.	**24**	**$13.95**
Ektachrome 1600, fast slide film	24	**$14.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

WRITE NO. 51 ON THE READER SERVICE CARD

STAR STUFF

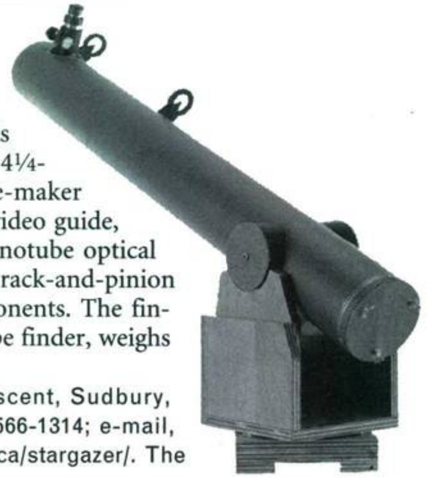
A PRODUCTS

Tripod and Pier for Small Telescopes

▶ NISUR systems introduces its *P3 TriPier* altazimuth mount for small telescopes. Wooden legs and a pier adjust to heights between 39 and 72 inches. Each mount features two trays, one for eyepieces and the other for extra accessories. The Model A eyepiece tray accepts 1.25- or 0.965-inch eyepieces; Model B accepts 1.25- or 2-inch eyepieces. The central pier incorporates a compass for alignment. The azimuth axis rides on sandwiched steel bearings. Cast acrylic forks with fine tension adjustments and locking knobs allow the telescope cradle to move in altitude. The cradle accepts telescope tube sizes from 2½ to 6 inches in diameter — specify the size when ordering. The entire tripod rolls along on locking caster wheels.

NISUR Systems, 50 Martin St., Bloomfield, NJ 07003; phone, (210) 566-9624; fax, (210) 566-9625. The *P3 TriPier Altazimuth Mount*: $298. Tripod and mount are available separately for $239 and $100, respectively.

Dobsonian Reflector Kit



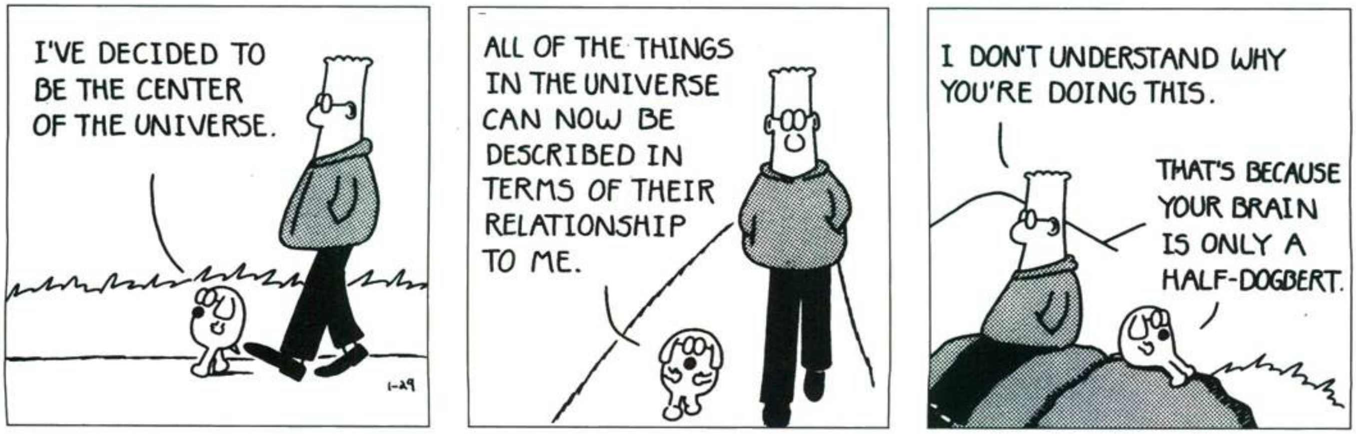
▶ A hammer, a screwdriver, an adjustable wrench, a small utility knife, and 7 pounds of sand are all you need to build your own 4¼-inch f/10 Dobsonian telescope. Telescope-maker Steve Dodson provides the rest: optics, a video guide, Teflon bearings, parts and hardware, a sonotube optical tube, a 10mm Kellner eyepiece, a 1¼-inch rack-and-pinion focuser, and birch plywood mount components. The finished telescope, which features a peep-scope finder, weighs 16 pounds.

Stargazer Steve, 1752 Rutherglen Crescent, Sudbury, Ontario, Canada P3A 2K3; phone, (705) 566-1314; e-mail, stargazr@isys.ca; website, http://ww2. isys.ca/stargazer/. The *Deluxe Reflector Kit*: $209, plus $29 shipping.

Pickup Truck Tent

▶ Convert the truck you use to haul equipment out under the stars into a portable sleeping or warm-up room with the *Sportz Truck Tent*. Five models that comfortably sleep two adults fit into the cargo beds of most pick-up trucks. Unpacking and setting up the tent, which stores in a pouch behind your seat, takes roughly 10 minutes. Fiberglass poles pop the dome-style tent up to a height of between 48 and 54 inches, depending on the model you buy. Bungie cords secure everything to truck sidewall tiedown points. The tent's polyurethane floor and polyurethane-coated nylon walls and rain fly keep out moisture and the elements. All models come with a one-year warranty. For a discount, mention that you saw this announcement.

Napier Enterprises, 2315 Whirlpool St., Suite 161, Niagara Falls, NY 14305; phone, (800) 576-2434 or (905) 935-0427; fax, (905) 643-8095; e-mail, mluke@vaxxine.com; website, http://www.vaxxine.com/trucktent. The *Sportz Truck Tent*: $139.95, plus $15 shipping in the U.S.


I'VE DECIDED TO BE THE CENTER OF THE UNIVERSE.
1-29
ALL OF THE THINGS IN THE UNIVERSE CAN NOW BE DESCRIBED IN TERMS OF THEIR RELATIONSHIP TO ME.
I DON'T UNDERSTAND WHY YOU'RE DOING THIS.
THAT'S BECAUSE YOUR BRAIN IS ONLY A HALF-DOGBERT.

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1.830	46.5	35.00	56.00[1]
2.140	54.4	68.00	90.00[1]
2.610	66.3	90.00	120.00[1]
3.100	78.7	105.00	135.00[1]
3.500	88.9	245.00	315.00[2]
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[1] surface flatness 10th wave or better.
[2] surface flatness 8th wave or better, 10th wave or better available by special order on these sizes.

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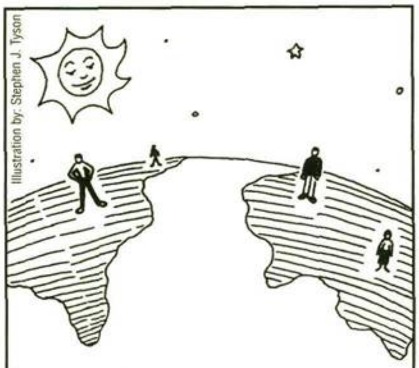
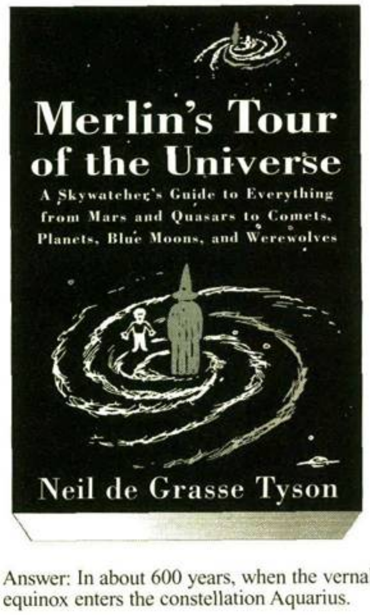


Illustration by: Stephen J. Tyson

Dear Merlin,

When does the "Age of Aquarius" start? (answer below)

People ask Merlin (also known as Neil de Grasse Tyson, Director of the Hayden Planetarium) some baffling questions, but he's always ready with authoritative, entertaining answers. In his new book *Merlin's Tour of the Universe* he'll enlighten you on everything from tides to quasars to life on other worlds. And, unless you're an astronomical wizard yourself, you'll learn a lot of wonderful new things.



Merlin's Tour of the Universe
A Skywatcher's Guide to Everything from Mars and Quasars to Comets, Planets, Blue Moons, and Werewolves
Neil de Grasse Tyson

Answer: In about 600 years, when the vernal equinox enters the constellation Aquarius.

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MAIN STREET BOOKS

BOOKS

Planet Quest: The Epic Discovery of Alien Solar Systems

Ken Croswell, 324 pages, The Free Press, New York, 1997; ISBN 0-684-83252-6, hardcover, $25.

Worlds Unnumbered: The Search for Extrasolar Planets

Donald Goldsmith, 237 pages, University Science Books, Sausalito, California, 1997; ISBN 0-935702-97-0, hardcover, $28.50.

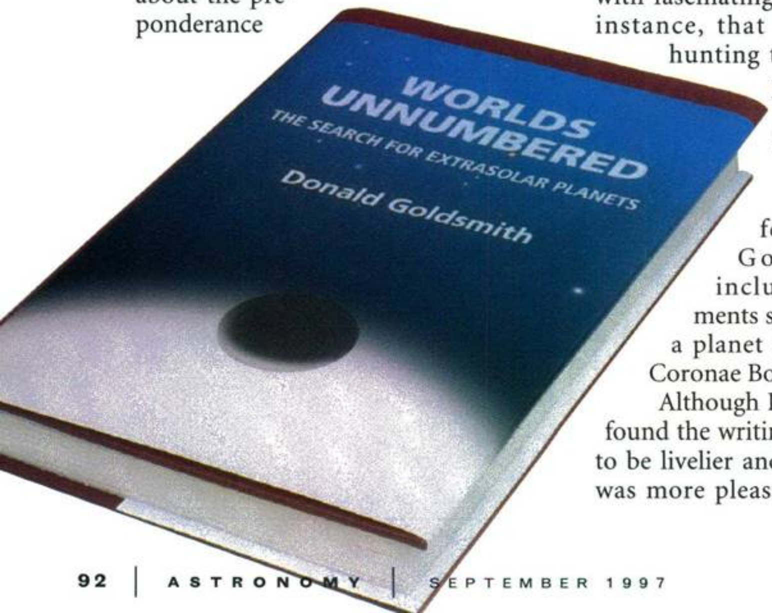
▶ Deciding when to buy a book about extrasolar planets is like deciding when to buy a new personal computer: You know that as soon as you buy one, it will be outdated. But if you're looking for a book about planets outside the solar system, now is probably as good a time as any to take the plunge and spend the $30 because the initial flurry of discoveries appears to be over.

Already you have a couple of titles to choose from, though these are clearly just the first two shots in the extrasolar planet book war. First up is *Worlds Unnumbered* by veteran astronomy writer Donald Goldsmith, author of *The Astronomers, Einstein's Greatest Blunder?* and several other popular astronomy books. Goldsmith delivers eloquent, accessible explanations and analyses of how these planets were discovered and what other techniques might be bearing fruit in the coming years.

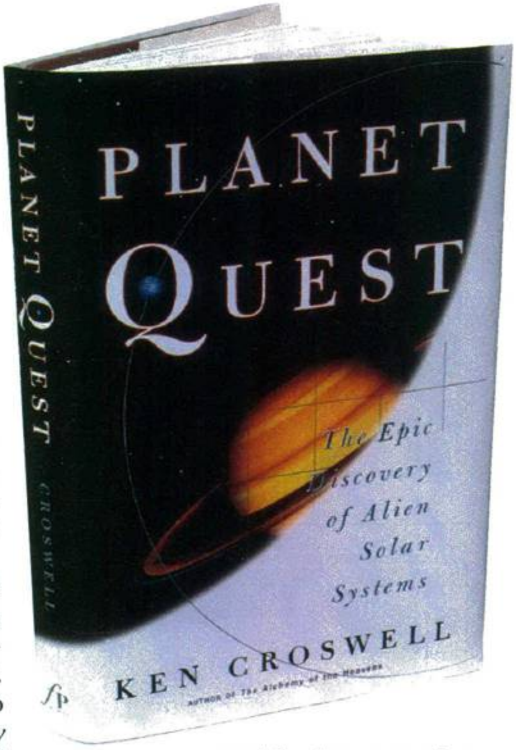
The book's primary focus, however, is what these new planets are telling us about the preponderance of life in the universe. Goldsmith's treatment of the requirements for life and the type of worlds that could support life is probably the best I've read on this subject. But I found his preoccupation with extraterrestrial life distracting. Clearly, the planets found to date do not offer much hope for life, yet Goldsmith devotes page after page to peripheral subjects such as SETI, UFOs, and alien abductions. In addition, the book's organization is somewhat disjointed.

In contrast, *Planet Quest*, which hit bookstores in August, goes into much greater depth about the planets themselves and the process of discovery. Croswell, a frequent past contributor to *Astronomy* and author of *The Alchemy of the Heavens*, takes a chronological approach. This leads to much tighter organization, and it also allows him to put the current discoveries in their proper historical context. For example, Croswell delves much deeper into the discovery of the first planets outside the solar system: the pulsar planets found by Alex Wolszczan and Dale Frail. In contrast, Goldsmith writes little about the pulsar planets because they are unlikely to support life.

Croswell digs deep into the controversies and personalities surrounding the discovery of extrasolar planets. His book contains more quotes from the researchers, and after reading the book, you feel as if you know who they are. You witness the drama of discovery unfolding, and you empathize with the hopes and frustrations of the astronomers. *Planet Quest* is strewn with fascinating tidbits including, for instance, that a Canadian planet-hunting team used the deadly poisonous gas hydrogen fluoride in its spectrograph. And because the Croswell book was published a few months after the Goldsmith book, it includes recent developments such as the discovery of a planet orbiting the star Rho Coronae Borealis.



Although I enjoyed both books, I found the writing style in *Planet Quest* to be livelier and more engaging, so it was more pleasurable to read. Goldsmith gives you the facts and explains the science well, but Croswell weaves these facts together into a story. The organization in *Planet Quest* is more coherent, and by delving into the history, which is rife with false alarms and stumbling, bumbling, and fumbling, Croswell does a magnificent job of providing a broad perspective of the entire subject.


PLANET QUEST
The Epic Discovery of Alien Solar Systems
KEN CROSWELL
AUTHOR OF The Alchemy of the Heavens
fp
PLANET QUEST
CROSWELL

For those who are primarily interested in how planets serve as platforms for extraterrestrial life, buy Goldsmith's book. But for those who want some insight into the workings of science, and for those who think these planets are interesting in their own right, buy Croswell's book. — *Robert Naeye*

BYTES

Linux for Astronomy

▶ Do you need the most popular Linux astronomical data processing packages? The second release of *Linux for Astronomy*, a CD-ROM compiled for use with the Linux operating system, provides comprehensive tools for specific tasks, such as CCD image processing, spectral analysis, photometry, and astrometry. In addition, several general purpose packages, including IRAF, MIDAS, STSDAS, and others, offer many image processing functions that are also useful in other disciplines. Major changes from Volume 1 include the addition of PGPLOT, MIRIAD, and GIPSY, add-ons for IRAF, updates to

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Hardly a day goes by that we don't get a note like the one reprinted below, or a call that goes something like this: "Your ads are right. So and so on the East Coast advertises low prices – but they don't have what I want in stock, they couldn't answer *any* of my questions, and they wanted my credit card number before they'd even *talk* to me. They said if I wanted to ask questions, I should call the manufacturer . . . and then they hung up on me!" One of our customers added, "If I wanted that kind of abuse, I would have called my ex-wife."

You need more than a camera store clerk with a price list and a wild guess to help you pick the right scope. You need someone who will take the time to listen to what *you* need, someone with the experience to help *you* get the most scope for your dollar. We've been helping people choose the right scope since 1979 at ***astronomics***. We have the experience to help you pick the scope and accessories that best fit your needs . . . *and your budget*. We're a family business. We don't work on commission, so we won't try to sell you something more expensive than you need just to pad our paycheck. We can't guarantee we'll have the perfect scope for everyone, but we'll do our best to help *you* pick the right scope from the more than 75 Meade, Celestron, TeleVue, Takahashi, Edmund, and Questar models we carry – priced from $299 to $45,000.

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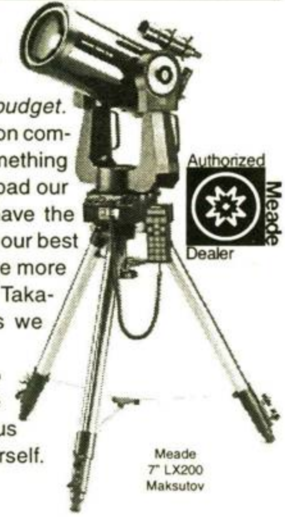
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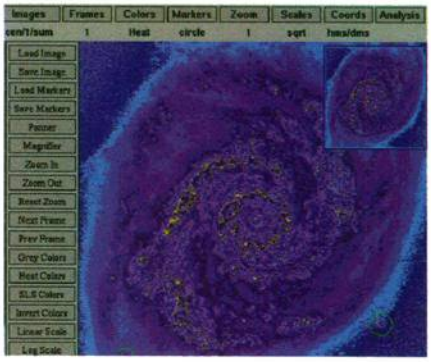
WRITE NO. 71 ON THE READER SERVICE CARD

all previously available packages, and the removal of AIPS, URLs, Windows programs, and mini-lux. A comprehensive set of HTML-format on-line documentation is provided, and a flexible installation tool lets you run most packages directly from the CD or install them on a hard disk.

The Random Factory, P.O. Box 12330, Tucson, AZ 85733-4070; phone, (520) 822-5221; fax, (520) 822-5223; e-mail, rfactory@earthlink.net; website, http://home.earthlink.net/~rfactory/lfa.html. Price: $35 for single issues of the CD, $55 for subscription updates (2 CD-ROM volumes). Minimum requirements: Linux 1.2 system version or higher.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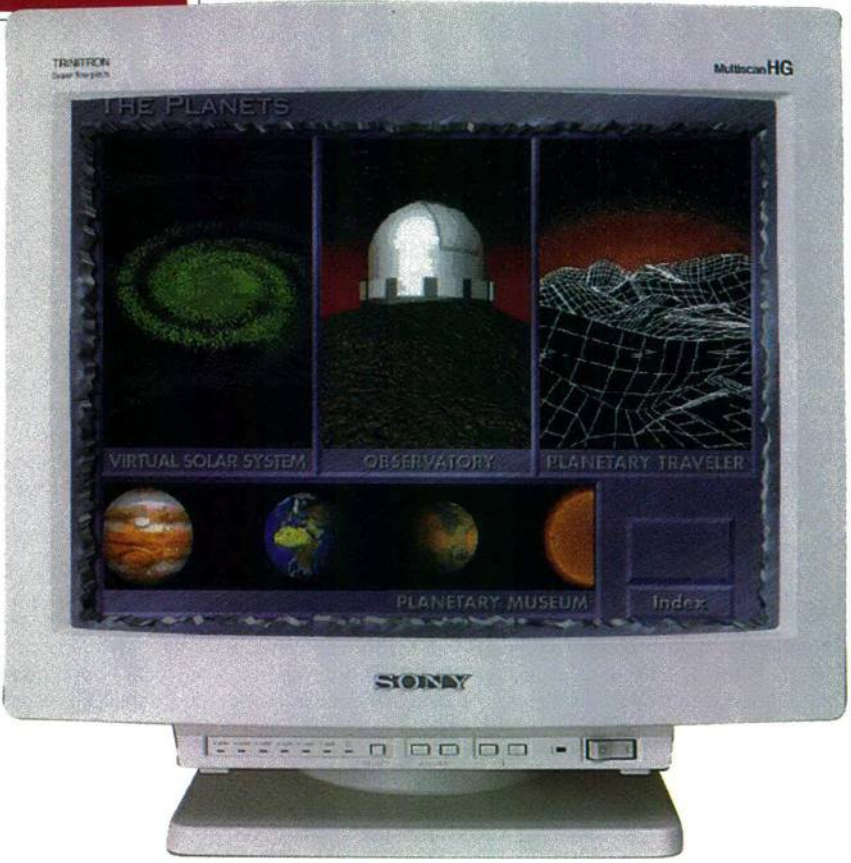
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The Universe and The Planets

▶ Two programs in one! This deluxe CD-ROM set from the Scientific American Library features *The Universe* and *The Planets* in a single package, for both Windows 95 and Macintosh computers.

The Universe is based on the acclaimed book *From Quarks to the Cosmos* by Nobel laureate Leon Lederman and David Schramm. It guides users on the ultimate tour of the universe from the tiniest building blocks of matter to the deepest edges of known space. A virtual laboratory simulates high-tech experiments, a series of tool kits lets users manipulate objects and events across the universe, an interactive timeline charts the discoveries in physics made over the past 2,000 years, and interviews with 17 leading cosmologists, high-energy physicists, and astronomers shed light on the people behind the science.

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Byron Preiss Multimedia Company, 24 West 25th Street, New York, NY 10010; phone, (212) 989-6252; fax, (212) 989-6550; e-mail, welcome@bmpc.com; website, http://www.byronpreiss.com. Price: $39.95. Minimum requirements: For use with both Windows 95 and Macintosh computers. Contact the manufacturer for details. ■

The Webweaver Picks

September is Asteroid month in Astrobytes.

Gordon Garradd's Asteroid Page
http://usrwww.mpx.com.au/~gjg/

How-To Guide to Minor-Body Astrometry
http://cfa-www.harvard.edu/cfa/ps/info/Astrometry.html

International Astronomical Union Minor Planet Center Page
http://cfa-www.harvard.edu/cfa/ps/mpc.html

Links to Resources on Near Earth Asteroids
http://cfa-www.harvard.edu/~marsden/SGF/links.html

Near-Earth Asteroid Tracking Program Page
http://huey.jpl.nasa.gov/~spravdo/neat.html

Spaceguard Foundation Page
http://cfa-www.harvard.edu/~marsden/SGF/

Asteroid 4179 Toutatis Page
http://www.eecs.wsu.edu/~hudson/Toutatis/toutatis.html

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The **Okie-Tex Star Party**, rated by *Astronomy* as one of the top ten, will be held September 30–October 4 at beautiful Lake Murray State Resort Park near Ardmore, Oklahoma. Along with a full line-up of guest speakers, there will be five days of swap-meets, cookouts, fishing, boating, horseback riding, and, most importantly, clear, dark nights for observing the universe.

Astrofest, Nightfall, Astroblast, Okie-Tex — prominent star parties bring summertime's sleepless nights of stargazing to a satisfying end.

AUGUST 29-SEPTEMBER 1

Alberta Star Party

▶ Eccles Ranch, Caroline, Alberta, Canada. For advance registration, contact Rick or Carol Weis, 4612 17th Avenue N.W., Calgary, T3B 0P3; e-mail, weisc@cadvision.com.

AUGUST 29-SEPTEMBER 1

Nova East '97

▶ Fundy National Park, Alma, New Brunswick, Canada. Sponsored by the Royal Astronomical Society of Canada's Halifax Centre. Contact Paul Gray, 49½ Windmill Road, Dartmouth, Nova Scotia, B3A 1C6; (902) 469-0947; e-mail, pgray@hercules.stmarys.ca.

SEPTEMBER-NOVEMBER

Sidewalk Gatherings and Star Parties

▶ Several events will be held at the Sequoia and Kings Canyon National Parks, Three Rivers, California. Sponsored by Sequoia Astronomical Society. Contact Hal M. Taliaferro, P.O. Box 10, Three Rivers, CA 93271; e-mail, h9000@ calwest.net.

Alfred Washburn

Gear up for nighttime exploration at the Connecticut Star Party, September 26–28.

SEPTEMBER 5-7

Astroblast '97

▶ Oil Region Astronomical Observatory, Two Mile Run County Park, Franklin, Pennsylvania. Contact Oil Region Astronomical Society, P.O. Box 351, Reno, PA 16343; John O'Hara, (814) 677-3972; e-mail, ohara@galacticis.com.

SEPTEMBER 5-7

Astrofest '97

▶ Camp Shaw-Waw-Nas-See, near Kankakee, Illinois. Sponsored by the Chicago Astronomical Society. Mail-in registration must be postmarked no later than 8/16/97. There is a significant fee increase after that date. Contact Astrofest '97, P.O. Box 596, Tinley Park, IL 60477-0596; voicemail, (773) 725-5618, press 3.

SEPTEMBER 6

Star Party

▶ Spring Mill Pond, Island Lake Recreation Area, Brighton, Michigan. Contact Ford Amateur Astronomy Club, P.O. Box 7527, Dearborn, MI 48121-7527; (313) 390-5456; website, http://kode.net/~dougbock/faac/.

SEPTEMBER 20

Astronomy Forum

▶ Five Towns College, Dix Hills, New York. Sponsored by the Astronomical Society of Long Island. Contact Ron Rizzi, (516) 795-3072.

SEPTEMBER 22

Sun Fest: Autumnal Equinox Celebration

▶ Adler Planetaruim, 1300 South Lake Shore Drive, Chicago, Illinois 60605. Contact (312) 322-0304; 24-Hour Information Line, (312) 922-STAR; website, http://astro.uchicago.edu/adler/.

SEPTEMBER 22-28

Great Plains Star Party

▶ Mound City, Kansas. Sponsored by the Kansas Astrophotographers and Observers Society. Contact Dan Johnson, 15506 Beverly Court, Overland Park, KS 66223; (913) 897-0235; or Rob Robinson, e-mail, robinson@sky.net.

SEPTEMBER 26-27

AAAA — Abegweit Autumnal Astronomical Adventure Regional Star Party

▶ Summerside, Prince Edward Island, Canada. Sponsored by the Athena Community Astronomy Club. Alternate dates October 3–4. Contact William Thurlow, (902) 436-1083.

SEPTEMBER 26-27

Dark Sky Party

▶ Cathedral Gorge State Park, Panaca, Nevada. Sponsored by the Las Vegas Astronomical Society. Contact Jim Mellor, 2052 High Mesa Drive, Henderson, NV 89012; (702) 361-1356; e-mail, jbar2@vegas.infi.net.

SEPTEMBER 26-27

Nightfall '97

▶ Palm Canyon Resort, Borrego Springs, California. Contact Bob Stephens, Fox & Stephens CPAs, 9045 Haven Avenue, Suite 109, Rancho Cucamonga, CA 91730; (909) 980-6050.

SEPTEMBER 26-28

Connecticut Star Party

▶ Colebrook, Connecticut. Sponsored by the Astronomical Society of New Haven. Contact Linda Marks at the Astronomical Society of New Haven, P.O. Box 3005, New Haven, CT 06515; (203) 874-4816.

SEPTEMBER 26-28

South Jersey Star Party

▶ Belleplain State Forest, Cape May County, New Jersey. Contact Paul Ostwald, 23 Isaacs Lane, Egg Harbor Twp., NJ 08234; (609) 293-1584; e-mail, paostwald@aol.com.

SEPTEMBER 26-28

Autumn Equinox Star Party

▶ Otter Creek Astronomical Observatory, 850 Otter Creek Park Road, Brandenburg, Kentucky; (502) 583-3577 or (502) 942-3641.

SEPTEMBER 30-OCTOBER 4

Twin Lakes Star Party

▶ Land Between the Lakes National Recreation Area, Golden Pond, Kentucky. Sponsored by the West Kentucky Amateur Astronomers. Contact Ross Workman, 508 Park Avenue, Dawson Springs, KY 42408; (502) 924-2243 (work) or (502) 797-8959 (home).

SEPTEMBER 30-OCTOBER 5

Okie-Tex Star Party

▶ Group Camp #3, Lake Murray State Resort Park, Ardmore, Oklahoma. Contact Steve Adkins, 7000 Pebble Lane, Oklahoma City, OK 73132; (405) 722-1678; e-mail, seadkins@icon.net; website, http:// www.icon.net/~seadkins/okie-tex.html.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to tconley@astronomy.com.

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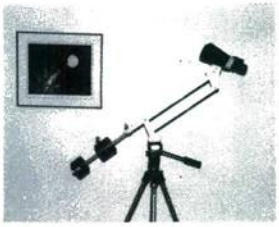

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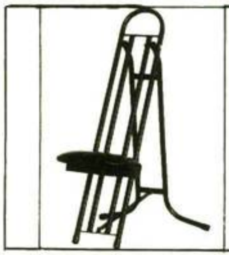

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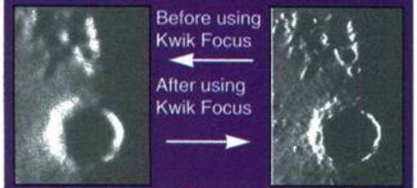

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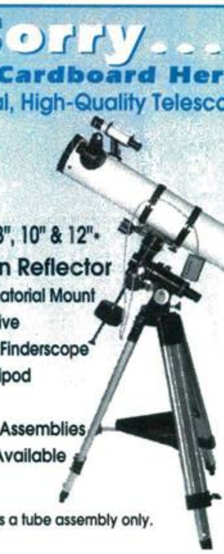

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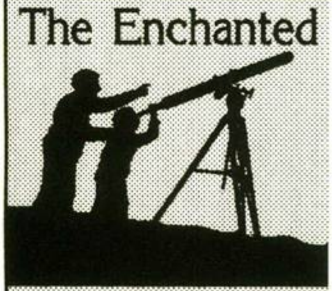

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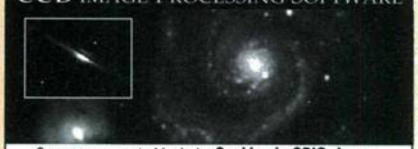

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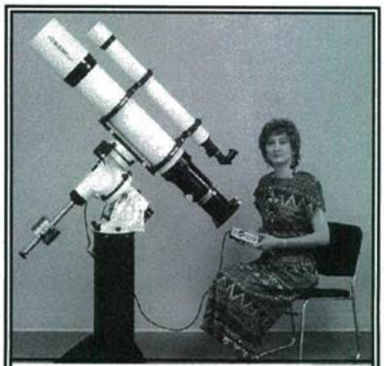

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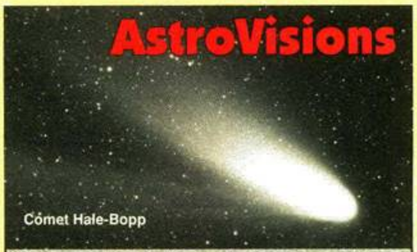

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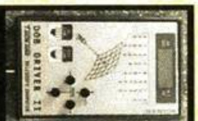

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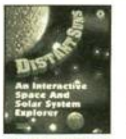

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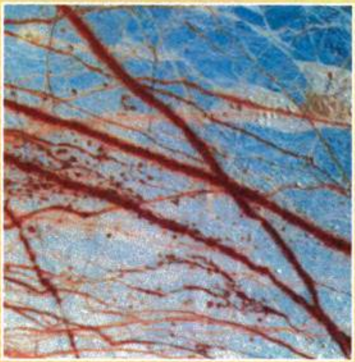
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AD INDEX

Adirondack Video Astronomy	100
Adorama	106, 107, 120
American Outdoors	103
Analytical Scientific	109, 120
Astro-Physics	104
Astronomics	28, 104
Astronomy Shoppe	108, 120
Astrosystems, Inc	103
Ball Photo Supply	108
Beigle/Bryant Engineering	105
Bergen County Camera	120
Berger Brothers Camera Exchange	108
Bethany Sciences	100
Blue Sky Pages	108, 109
Bondono Software	101
Bruce Johnston Computing	104
CBH Travel	102
CC Sales/Camera Corner	120
CWK Associates, Inc.	101
Camera Bug	108, 120
Captain's Nautical Supplies	120
Michael I. Casper Meteorites	103
Celestron International	59, 122
Cruise Holidays	100
DGM Optics	104
Dark Matter Images	105
Darkroom Unlimited	100
Day Star	25
Dover Photo Supply	120
EKV Productions, Inc.	101
Eagle Optics	109, 120
Edmund Scientific Company	25
Edward R. Hamilton Bookseller	100
Efstonscience, Inc.	109
Enchanted Skies Star Party	103
eOptics	91
FC Meichsner Company	120
Focus Camera	71
Franklin Spier, Inc.	91
G O A Cosmos	102
Harrison Scientific Instruments, Ltd	109
Helmer Publishing	104
International Optics Ltd.	102
Into the Wind/The Kite Source	103
JMB Inc	18
Jim Kendrick Studios	102
Jim's Mobile Industries	23
Kalmbach Publishing Company	25, 70, 91, 110, 119
Khan Scope Centre	109
Killgore Southwest	105
Kitt Peak National Observatory	17
Lasermax, Inc.	102
Lumicon	88, 89, 120
Mag One Instruments	103
Marketplace Pages	100, 101, 102, 103, 104, 105
Meade Dealer Pages	14, 15
Meade Instruments Corp	2, 3, 7, 8, 9, 10, 11, 12, 13
Minerva Press	104
Mountain Skies Astronomical Society	101
Murnaghan Instruments	91
New England Meteoritical	105
New Mexico Astronomical	108
Newbridge Communications, Inc.	19
Newport Glass Works	100
Nisur Systems	101
Nurnberg Scientific	108
Oceanside Photo & Telescope	120
Orion Telescopes & Binoculars	27
Outer Edge Expeditions	101
Walter Pacholka	101
Pegasus Optics	101
Pocono Mountain Optics	97, 98, 99, 120
QSP Optical Technology, Inc.	104
Rainbow Symphony	101
Rivers Camera Shop	97
Santa Barbara Instrument Group	21
Sarasota Camera Exchange, Inc.	108
Science Connection, Inc.	104
Scope City	58, 120
Shutan Camera & Video	29
Sita World Travel	101
Sky Optics	109
Smithy	103
Software Systems Company	25
Sovietski Military Connection	103
Starry Messenger	103
Starsplitter Telescopes	100, 105
Stellar Vision	108, 120
Surplus Shack	102
Tech 2000	105
Technical Innovations	18
Tele Vue Optics, Inc	121
Tele Vue Dealer Page	120
Telescope & Binocular Center	84, 85
Telescope Engineering	105
Total Adventures Ltd.	100
Travel Quest	102
Travel Wizard	105
Tropical Adventures	105
Roger W. Tuthill, Inc.	28, 58, 104
University of Colorado, Alumni Association	101
University Optics, Inc.	28
Vernonscope	105
Virgo Astronomics	102
What in the World	18
Wholesale Optics	95
Zephyr Services	102

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▶ "Aunt Renée! Aunt Renée!" came the calls through my door.

Teenage nieces, two of them, were knocking, beckoning me to come outside for something. I didn't know what it was, and at that moment, I didn't really care. I was propped gingerly against a fluffy down pillow, a light cotton T-shirt scratching my sunburned shoulders like sandpaper. All I wanted to do was sit in bed, chew a bunch of ibuprofen, and hope that I wouldn't shed all my skin by morning.

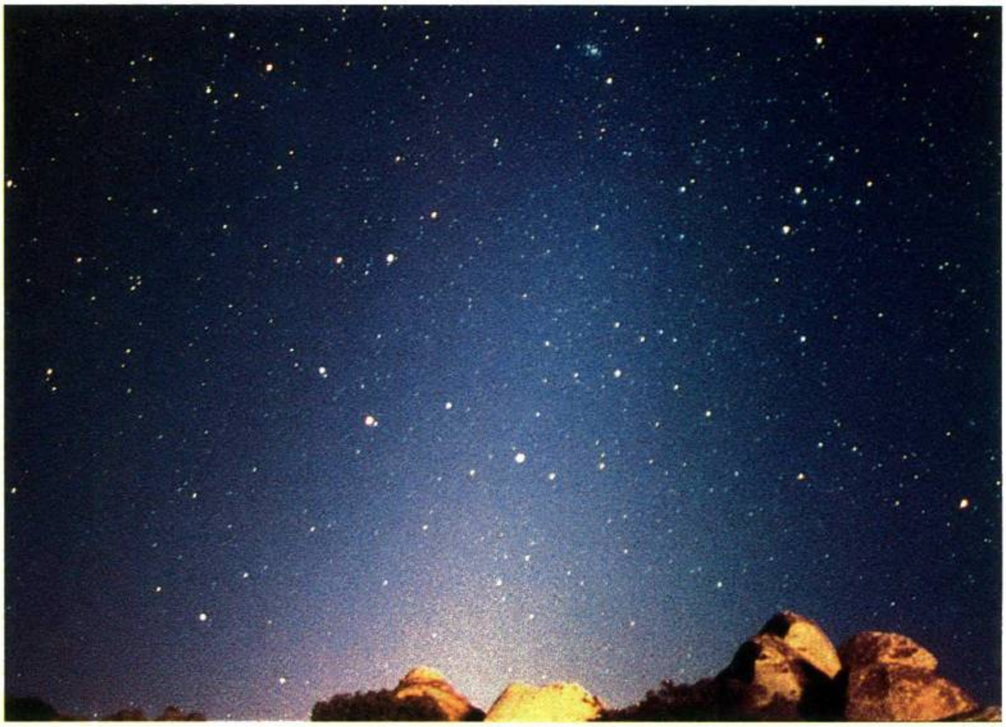
"Aunt Renée!" they persisted. I groaned. Didn't they know I was in pain? "Come outside and tell us what all these stars are!"

Stars?

I hopped out of bed, ignored the hot, searing pain in my shoulders, and flung open the door. Only the stars could have gotten my mind off my early afternoon stupidity of foregoing sunscreen.

We trotted outside, beyond the Olympic-sized pool, past the gazebo, and onto a plot of grass whose day job was to serve as a practice putting green. At this time of night it made a suitable observing pad, and the rest of the nieces and nephews and other assorted relatives had gathered there to crane their necks skyward.

"Is that Jupiter?" one niece asked.



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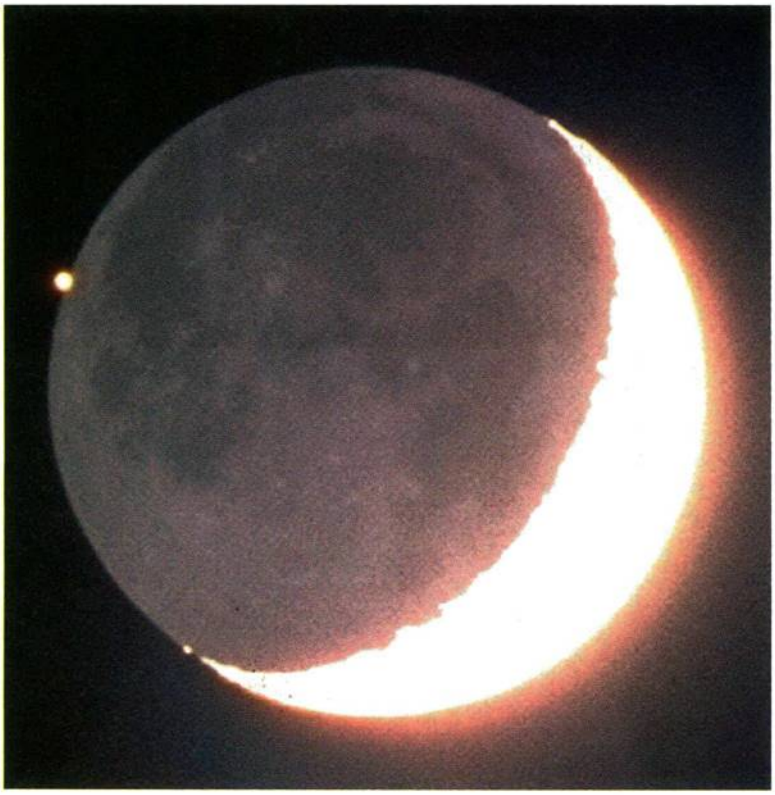
JERRY SCHAD

(24mm lens at f/1.4, Ektachrome P1600 film at ISO 3200, 60-second exposure)



The Moon Occults Aldebaran

MICHAEL STECKER

(5-inch f/6 refractor, Kodak Gold 400 film, 5-second exposure taken on April 10, 1997)

I followed her gaze to a bright spot in the sky. "Yep," I replied, more than a little impressed that a non-astronomer knew where Jupiter was.

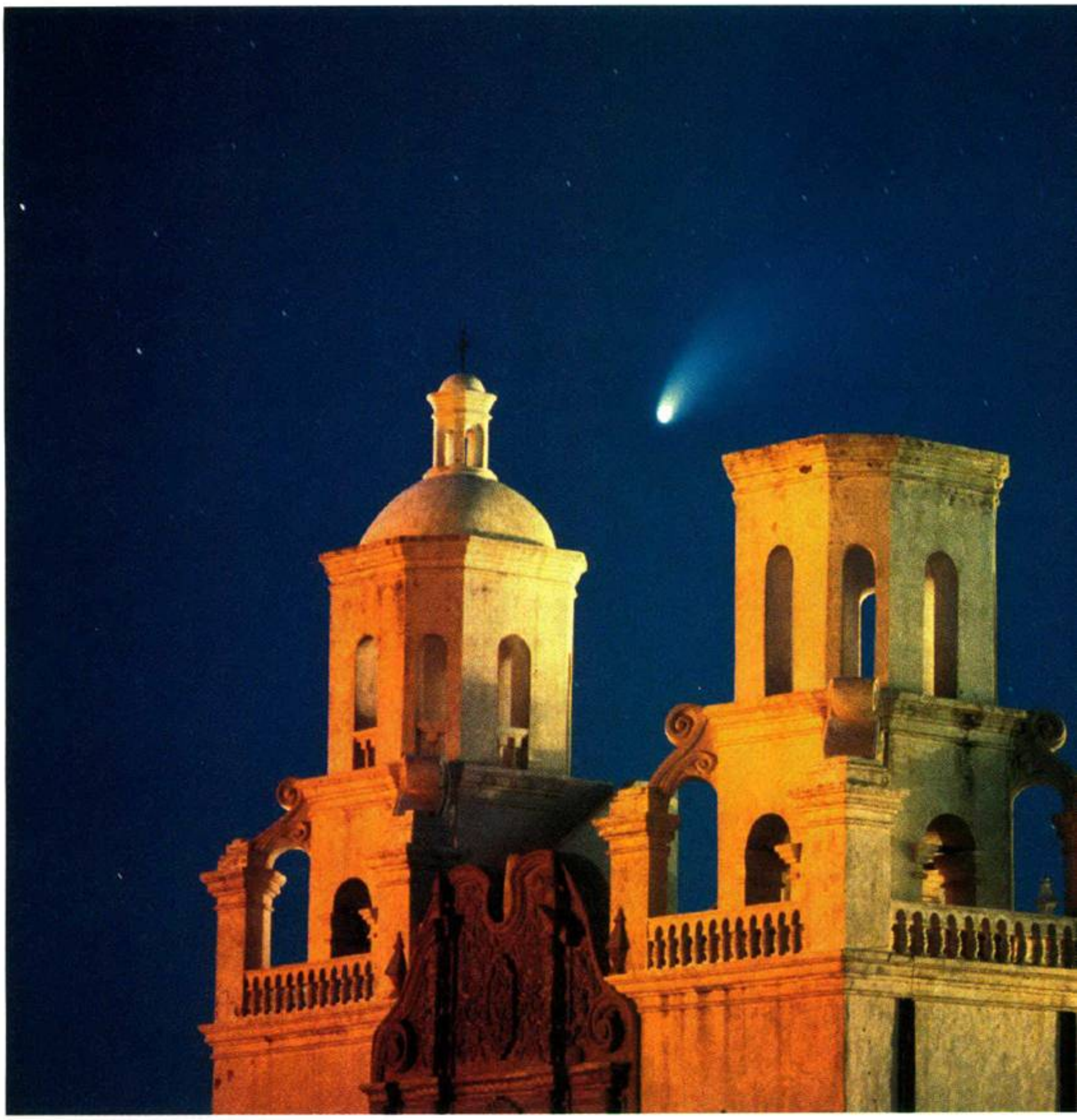
"Is that Orion?" a nephew inquired. No, I explained, Orion wasn't up at this time of the year. That was Scorpius. I pointed out the roughly-scorpion shape, the red "heart" star Antares, and explained that there were tons of fuzzy patches near its tail that'd really look cool if seen through binoculars. Family members moaned that they'd forgotten to bring any.

The next logical constellation was Sagittarius, another haven of "cool-looking fuzzy patches." Since I've never been able to see anything resembling the shape of an archer in that particular collection of stars, I decided to go with the teapot image that corrupted my youthful stargazing — you know, where the spout pours onto the tail of Scorpius.

The archer image didn't work for them, either; the teapot did.

"They think the center of the galaxy's right over there," I explained, still pointing in the direction of Sagittarius. My audience paused reverently to consider the motion of Earth and sun and stars around that distant glow. When I figured they'd digested that, I continued. "Astronomers think there's a black hole in the center of the galaxy."

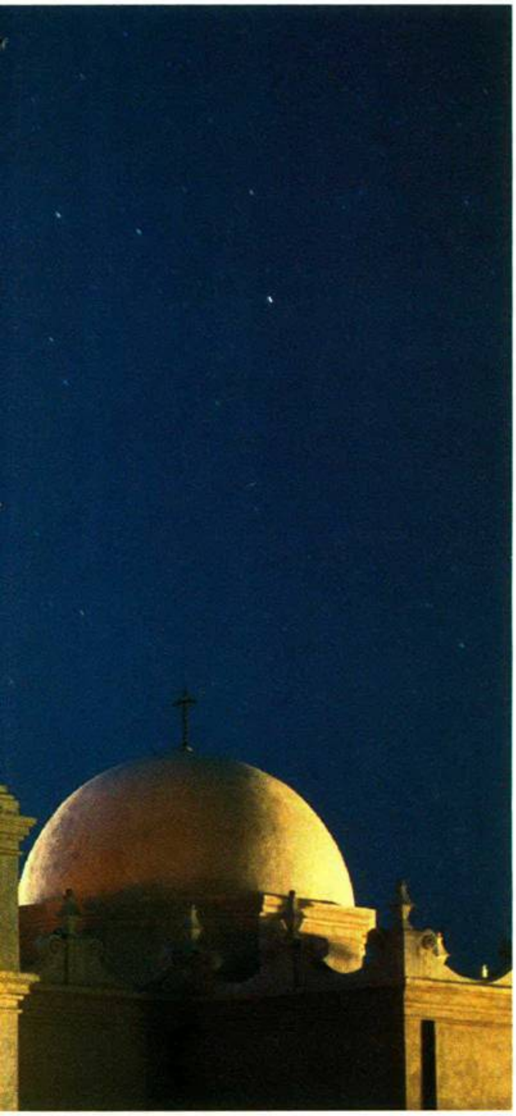
I always like to preface my astronomy factoids with, "astronomers think," or astronomers theorize." It's not that I doubt the scientific methods of professional astronomers. Many competent practitioners of science hold wildly divergent



Late Night Star Trails through a Tree

ALBERTO OLTOLINI

(50mm lens at f/4, Kodak Elite II 400 film, 15-minute exposure)



Hale-Bopp over an Arizona Mission

KEN MATESICH

(105mm f/2.5 lens, 4x5 camera, Kodak Gold 800 film at ISO 1600, 30-second exposure taken on April 12, 1997)

Hale-Bopp above Bora Bora

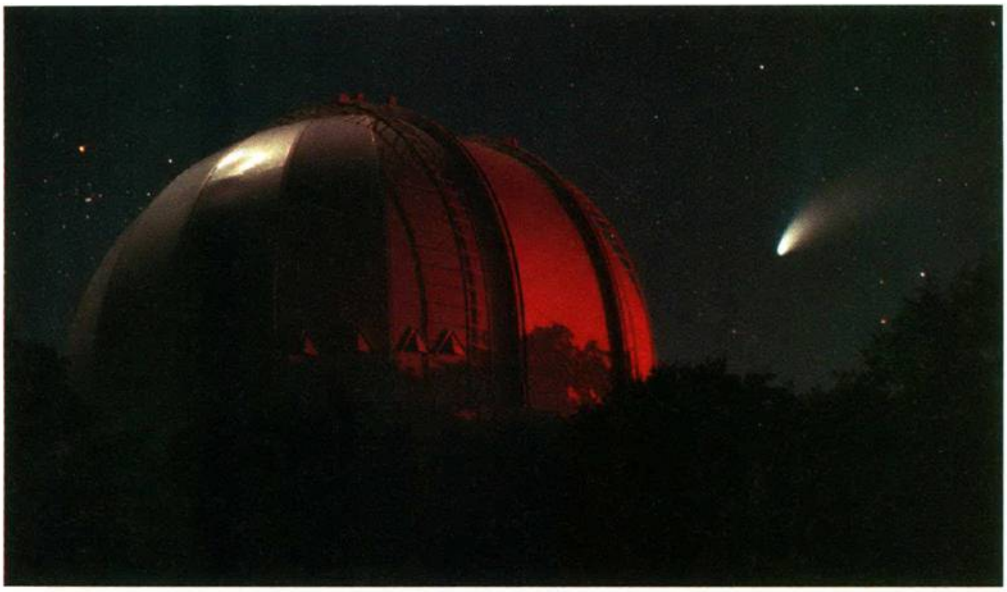
YVES ESVAN

(50mm lens at f/1.8, Kodak Tech Pan 2415 film, 30-second exposure)

Hale-Bopp with Kitt Peak Observatory

JOHN WELLBELOVED

(50mm lens at f/2, Fuji Super G 800 film, 20-second exposure on April 13, 1997)



views on the universe's age.

But the family didn't care. They were busily searching the heavens for other objects that interested them. What's that bright star? Arcturus. All you have to do is keep going in the same arc from the handle of the Big Dipper and you get to Arcturus. See?

I could have gone on and on about the temperature and chemical composition and spectral type and age of Arcturus. But I've found that sometimes it's best just to give the name and let them wonder about the rest.

And wonder they did. About everything. Where's the North Star? Good, another easy question. And the Little Dipper is right there with it. Does the North Star set? Why do some stars flicker in different colors? Is that big cloudy strip all made out of stars? I think we covered Astronomy 101 that night, and everyone was loving it.

Finally, the night had crept far enough along, and we all decided to end class.

As I made my way back to my room, one of my relatives, making a concerted effort not to use the word "astrology" around me, gave me a quick hug and said sincerely, "Thanks for the great anatomy lesson."

Well, next summer we'll work on identifying scientific disciplines . . .

— *C. Renée James*

James is an astronomy enthusiast and instructor at Austin Community College in Texas.

Send reports, stories, photographs, and disks to Hot Shots editor, Astronomy, *P.O. Box 1612, Waukesha, WI 53187-1612. Send written reports via the Internet to: hotshots@astronomy. com.*

Gamma (γ) Cygni Region

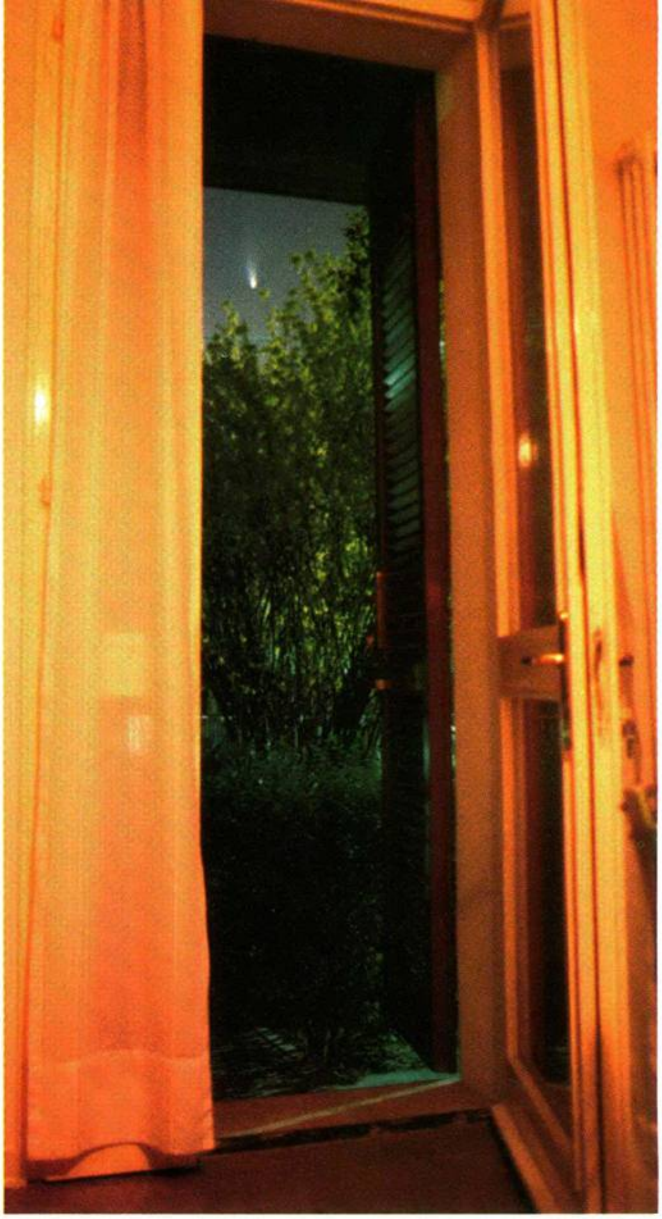
VINCE AND MAGGIE FARNSWORTH

(4-inch f/5 refractor, Fuji SG 800 film, composite of two 45-minute exposures)

Emission Nebula Sharpless 2-132 in Cepheus

GEORGE GREANEY

(6-inch f/7 refractor, medium format camera, hypered Fuji SHG 400 film, composite of two 60-minute exposures)



Hale-Bopp, the Doorway Comet

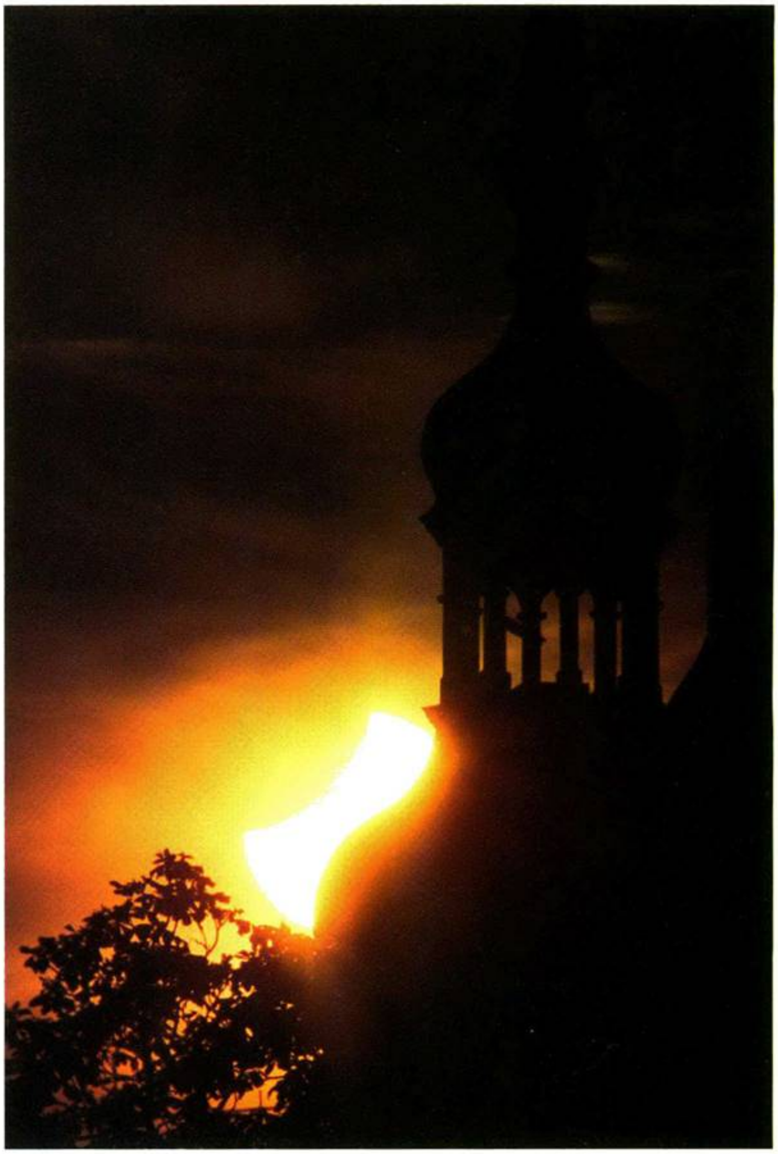
ENRICO MONTANARI

(50mm lens at f/2.8, Kodak Extapress 1600 film, 30-second exposure, foreground filled in by flashlight, taken on March 16, 1997)

Hale-Bopp Sails over the Golden Gate Bridge

PAUL GESSLER

(35mm lens at f/3.5, Kodak Tri-X Pan film, 60-second exposure on March 28, 1997)



Partial Solar Eclipse behind a Church in Poland

TOMASZ KAMIENIK

(600mm lens at f/22, Agfacolor 100 film, 1/2000-second exposure taken on October 12, 1996)

The Heart of the Virgo Galaxy Cluster

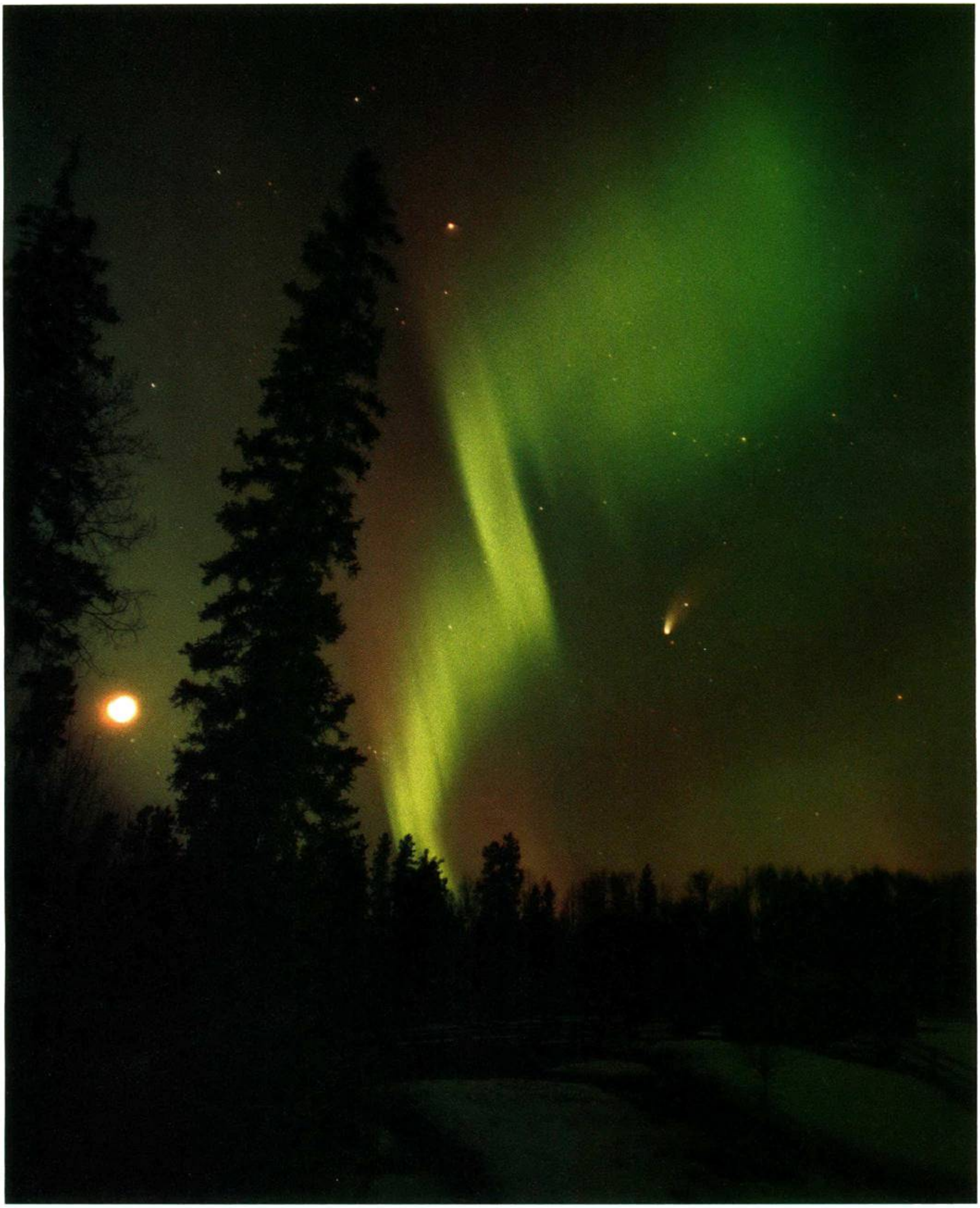
VINCE AND MAGGIE FARNSWORTH

(4-inch f/5 refractor, Fuji SG 800 film, composite of two 45-minute exposures)

A Leonid Meteor Streaks through Canis Major

FRANK ZULLO

(24mm lens at f/5.6, Kodak T-Max 3200 film, 6-minute exposure duped with a horizon onto Kodak 5072 film)

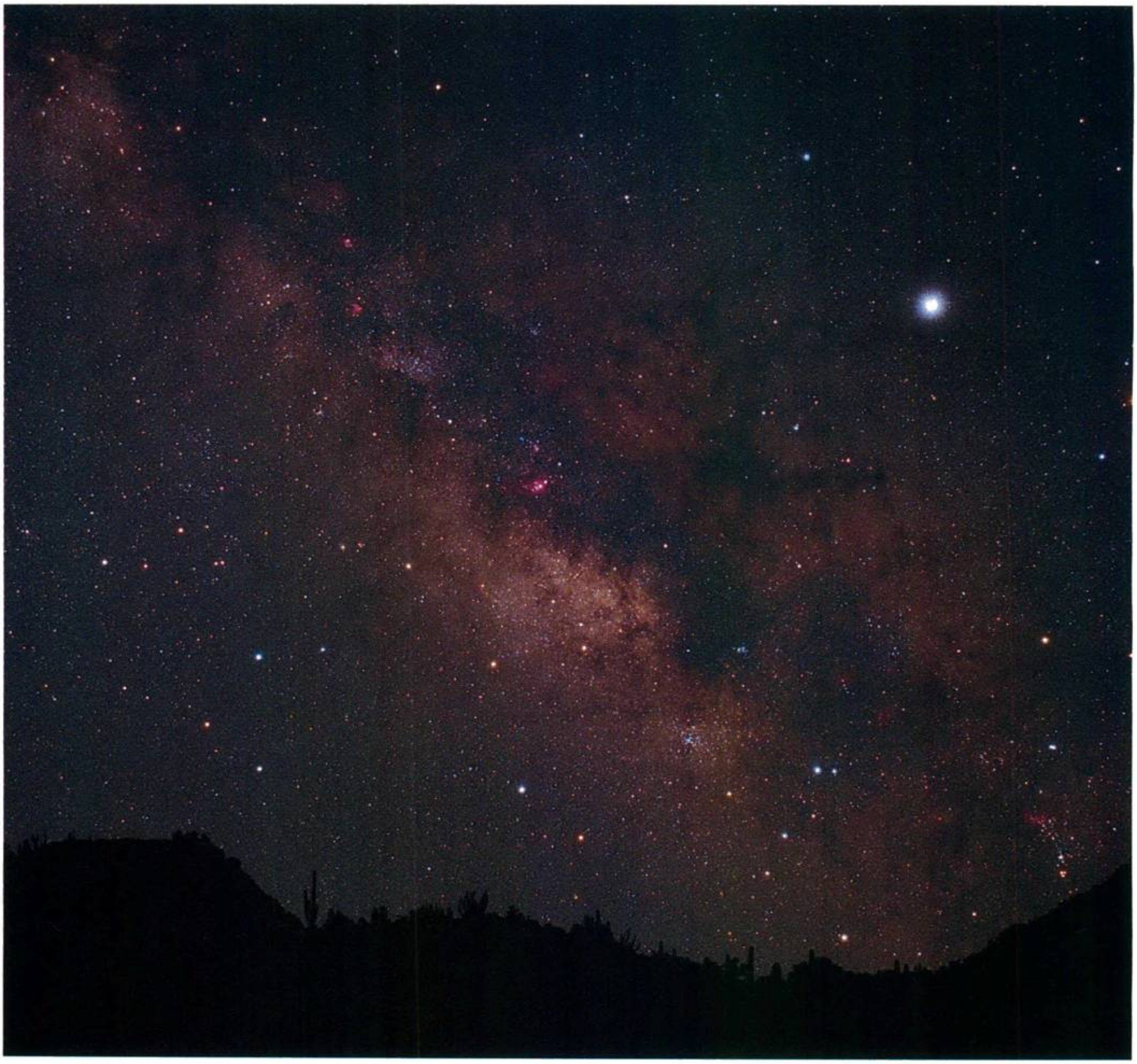


Hale-Bopp through Curtain Aurora

JIM FINK

(24mm lens at f/2.5, Fuji Super G Plus 800 film, 40-second exposure on April 10, 1997)

This month's best astrophoto



Summer Milky Way Horizon

FRANK ZULLO

(28mm lens at f/4, Fujicolor HG 400 film, 27-minute exposure with foreground added when converted to a slide)

Here's a snapshot of summer: Perched above the horizon is the Teapot of Sagittarius (left) and the hooked form of Scorpius (right). Left of the scorpion's stinger stars lie M6 and M7, two open star clusters that are stunning sights through binoculars. Arrayed behind the constellations and bright, white Jupiter is an edge-on view of the Milky Way Galaxy. Globs of dust block our view to the glow beyond. The brighter patch just below center is our galaxy's hub poking below interstellar dust.

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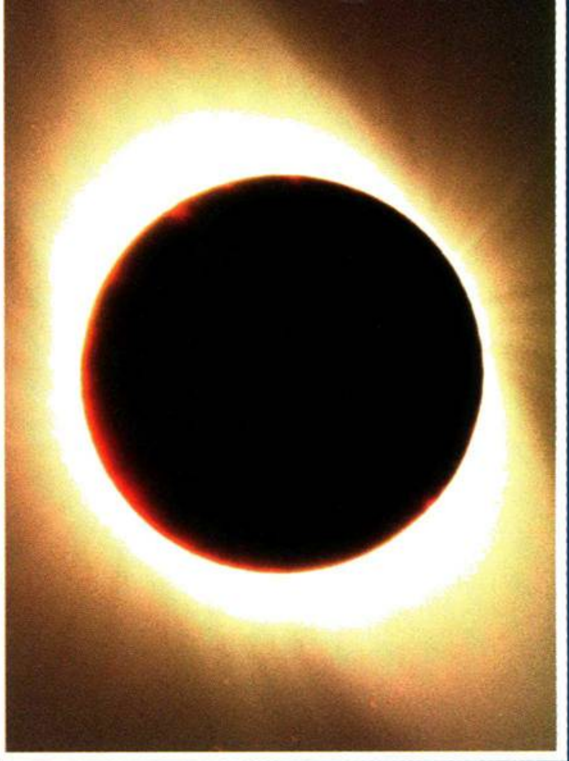

Eclipse photo taken by Ernest Piini.

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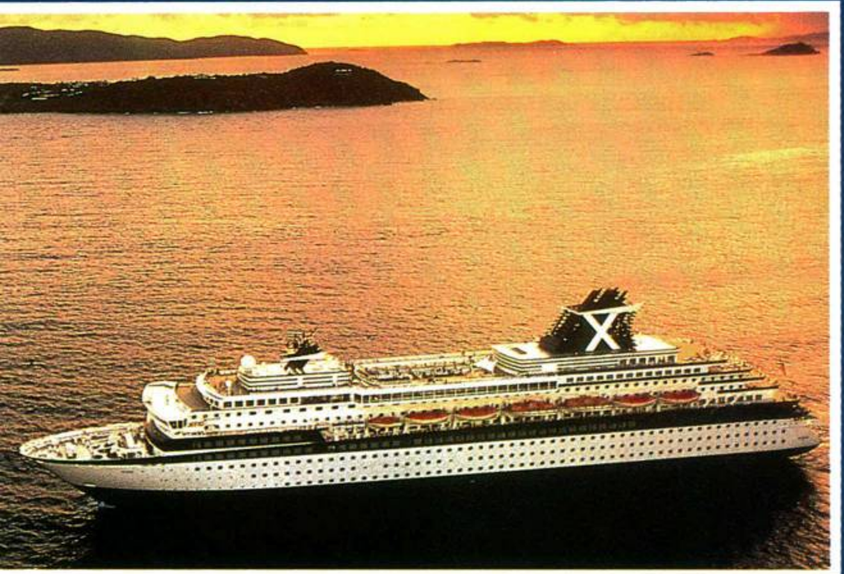

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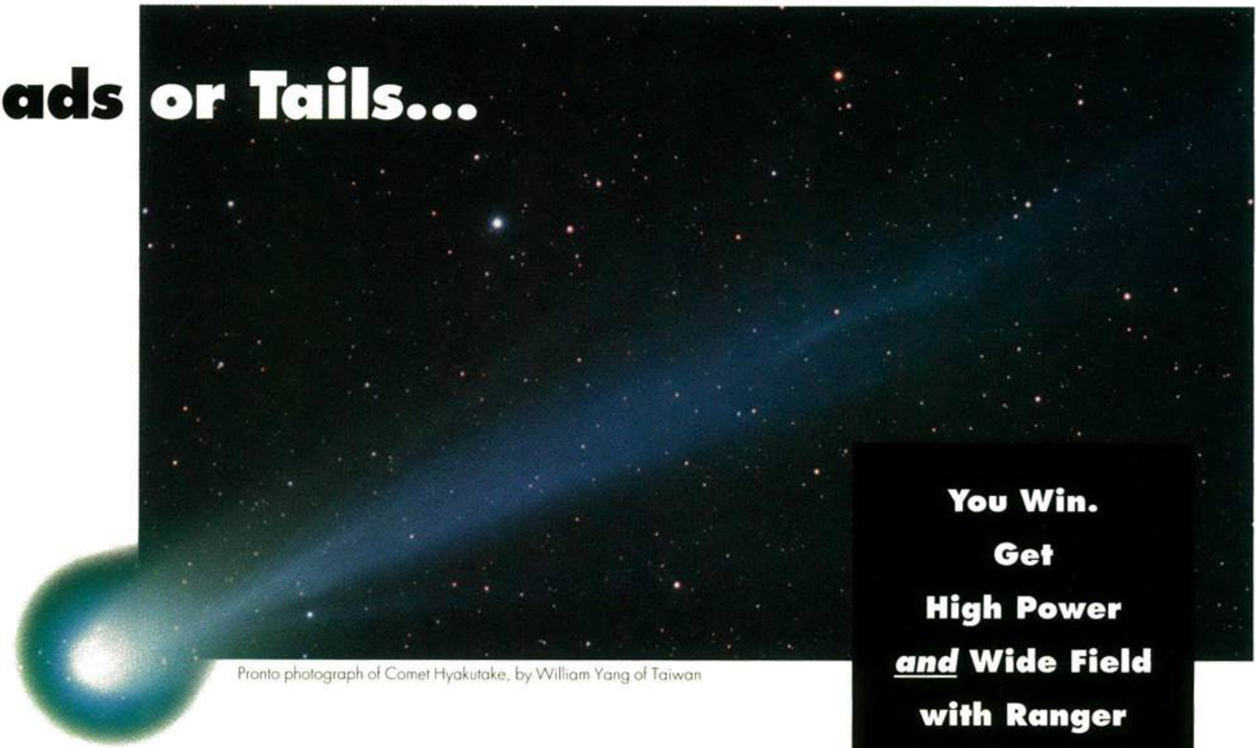
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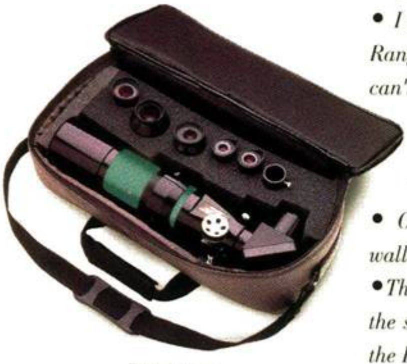
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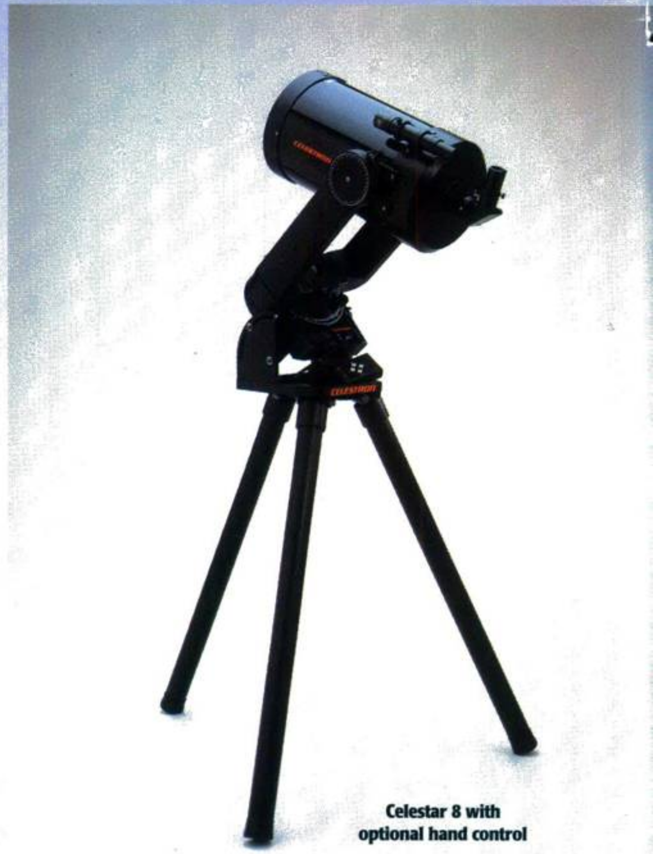

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